IOWA WATER CENTER
at IOWA STATE UNIVERSITY

GETTING INTO SOIL & WATER

2011

Soil & Water
Conservation Club

LETTER FROM THE SOIL & WATER CONSERVATION CLUB PRESIDENT

The Soil and Water Conservation Club is excited to present Getting into Soil and Water 2011. The purpose of this publication is to educate individuals about soil and water issues ranging from within the state of Iowa to around the world, also to peak interest in natural resource conservation. The Iowa State Soil and Water Conservation Club is grateful to be in an area where agriculture and soil and water conservation can come together. Our knowledge can be applied to conserve soil and water in one of the world's richest areas for agriculture. While on the Iowa State University campus, we feel it is our duty as a club to promote and teach conservation of our earth's greatest resources, soil and water.

Our club consists of many diverse individuals from various different backgrounds, who have taken it upon themselves to help improve public knowledge of soil and water conservation. It has become everyone's responsibility to maintain soil and water quality. Some of the ways our club members have made a difference are by collaborating with the Iowa SWCS and in presenting the ground water flow model. We have presented the ground water flow model on Iowa State Campus, elementary schools, and at various conferences and events dealing with soil and water conservation.

A big thank you goes out to everyone who has donated their time and efforts this year to increase awareness of the quality of our soil and water, especially to the publication contributors, committee members, and Lee Rudebusch, our publication editor. The success of the ISU Soil and Water Conservation Club would not be possible without help from its members and our advisors Dr. Rick Cruse and Dr. Amy Kaleita.

Sincerely,

Ashley Waller

SWCC President (2010)

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Editor

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MESSAGE FROM THE IOWA WATER CENTER

Jim Newman, Program Coordinator
Rick Cruse, Director

The Iowa Water Center is proud to participate in this annual student publication, Getting Into Soil and Water, now in its third year. Today's students and young farmers and professionals increasingly recognize the reality of the soil and water inter-relationship, and look beyond the narrow interests of past generations toward a way of life that will share the earth's bounty with their children. The natural resources profession has acknowledged the inseparability of our soil and water resources. We have learned to consider all natural resources as part of one complex system, with all natural resources and alterations to these resources having an impact on one another and directly impacting the quality of human life on the planet. It is our goal to educate and raise awareness of this critical connection as rising populations; increased food, feed, and fuel demands; and changing climate add production stress to our soil and water resources.

The challenge of today is to take the science of natural resources management to the broader community. A quick search for natural resources in Iowa on the internet will give beef, corn and soybeans as our state's most prominent natural resources, with rich soils as the source of this wealth of agricultural production. The gross domestic product (GDP) of agriculture in the United States has increased relative to the GDP of mining of non-renewable resources (metal, coal, oil and gas) (http://www.allcountries.org/uscensus/1145_gross_domestic_product_of_agriculture_forestry.html). An identical internet search for the nation of China gives much different data. Coal, iron ore, gas, tin, tungsten, mercury, manganese, aluminum, zinc, lead, uranium, the traditional/industrial natural resources elements, dominate the online conversation. The sense that China is now the strongest economy in the world tells us much about the importance given to soil and water resources and renewable agricultural production, compared to consumption of non-renewable products. To much of the world, natural resources are still materials to be extracted, used, and disposed as waste. Today's youth are charged with bringing a new definition of natural resources into the mainstream. This annual student publication is part of the shift toward a truly sustainable future.

> The natural resources profession has acknowledged the inseparability of our soil and water resources.

Developer
of sustainable systems

Sustainable agriculture systematically addresses many environmental and social concerns of the entire food system. Sustainable agriculture integrates three main goals: environmental stewardship, farm profitability, and prosperous farming communities.

Agronomists manage our plant and soil resources as a sustainable system through all of the interactions that support crop growth including the impacts on the environment and society. Agronomists integrate concepts of soil science, plant science, climatology, and social science.

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IOWA STATE UNIVERSITY
Department of Agronomy

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THE LIFE, NEAR-DEATH AND REBIRTH OF NAHANT MARSH

Brian Ritter
Facilitator of Nahant Marsh, Eastern Iowa Community College District

Nahant Marsh is a 513 acre complex of wetlands formed by ancient meanderings of the Mississippi River in southwest Davenport, Iowa. By the time of Euro-American settlement in the 1830's, the area was primarily a complex of shallow marshes and sedge meadows. Several small settlements in the area came and went as occasional flooding chased away all but the die-hard "river rats" and farmers. Evidence suggests that Nahant Marsh remained a fairly well intact ecosystem until the 1950's, when a series of events nearly destroyed the area.

Changes in agriculture during the 20th century led to changes in the hydrology of our landscape. Farmers surrounding the marsh tiled their fields and constructed a series drainage ditches through the marshlands. This appears to have resulted in an increased volume of water flowing into some areas of the marsh and also an increase in sedimentation. Changes in some of the plant communities followed, with an increase in cattails.

In addition to agricultural changes in the area, growing urbanization and industrialization provided further threats to Nahant Marsh. Several factories, warehouses, and junkyards began to appear in the area during the middle 20th century and with that came further pressures on the marsh environment in the form of habitat loss, noise and light pollution, and further changes in the hydrology of the area. Another major impact occurred in the late 1960's, when work began on Interstate 280. To construct the interstate, a large earthen berm was erected that essentially cut the marshlands in two. Although a culvert allows for water movement between the marshes, the interstate has had a clear impact in terms of the amount of water that Nahant Marsh now holds.

Possibly the most important event that shaped the history of Nahant Marsh was the presence of a gun club at the site from 1969 to 1995. A trap and skeet range at the marsh allowed area sportsmen and women to hone their shooting skills over the marsh. However, the wide-scale use of lead shot had disastrous effects on the marsh ecosystem. The club closed down after the US Fish and Wildlife Service confirmed that waterfowl were

Although it still faces significant challenges, Nahant Marsh stands as a symbol of the resiliency of nature.

being poisoned when they ingested lead pellets from the bottom of the marsh. Survey work at the site confirmed that at least thirteen acres were heavily contaminated with concentrations of lead in some spots exceeding 500 shot per square foot. As a comparison, "acceptable" levels at the time were considered to be less than ten lead shot per square foot. Not only were waterfowl suffering as a result of the contamination, but certain plant species were found to have had mutations as a result of exposure to lead. The contamination was possibly working its way up the food chain.

The long road to recovery came about when several area organizations banded together to get the marsh cleaned-up and to develop a new purpose for the area. Groups such as the Quad City Audubon Society and River Action, Inc. joined forces with City of Davenport and the US Fish and Wildlife Service to convince the US Environmental Protection Agency to take action. As a result, Nahant Marsh was declared a Superfund site and in 1998, a $2 million clean-up and restoration began on the thirteen most contaminated acres of the marsh. The area was drained and approximately 143 tons of lead-laced soil was removed from the marsh.

For the first time, in the history of the EPA Superfund program, after the clean-up was complete, the area was turned into a nature preserve and educational facility. The City of Davenport took possession of the 78 acres that had previously been owned by the gun club. The old club house was converted into an educational center and the non-profit Nahant Board was formed to acquire more land and oversee educational activities. Since the clean-up occurred, the area of land within the preserve has grown to 262 acres. The educational programming, headed up by the Eastern Iowa Community College District, now provides opportunities for over 6,000 people annually.

Although Nahant Marsh will probably never be exactly the same as it was prior to settlement, visitors are still able to experience a diverse ecosystem through low-impact recreational and educational opportunities and through Nahant's network of trails, boardwalks, bird-blind, and dock. Since the clean-up, over 360 plant species, 149 bird species, and numerous reptiles, amphibians, fish, and mammals have been observed at the marsh, including the State threatened Blanding's Turtle, the protected Ear-leaved false foxglove, river otters, beavers, and bobcats. Today, Nahant Marsh is thought to be the largest urban wetland on the Upper Mississippi River. Although it still faces significant challenges, Nahant Marsh stands as a symbol of the resiliency of nature.

WATER QUALITY BENEFITS OF WETLANDS IN AGRICULTURAL LANDSCAPES

William Crumpton,
Department of Ecology, Evolution and Organismal Biology, Iowa State University

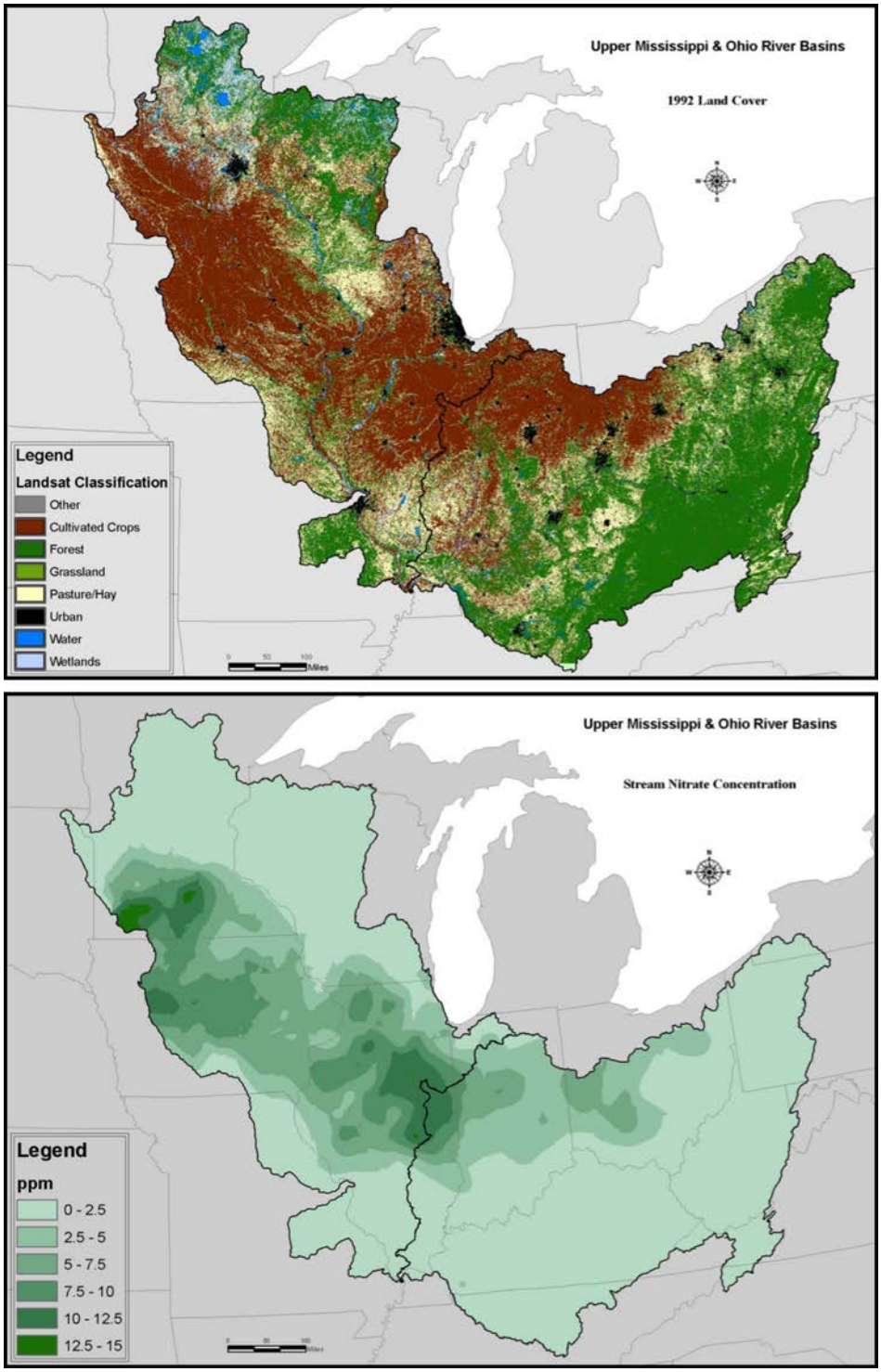

Figure 1. Land cover (top) and stream nitrate-nitrogen concentrations (bottom) in the Upper Mississippi and Ohio River basins (Derived from Landsat data and STORET and state data sets).

Agricultural applications of fertilizers and pesticides have increased dramatically since the middle 1960s and the impact of agrochemicals on water quality has become a serious environmental concern. Nitrate is a particular concern; (1) because of the potential adverse impacts on both public health and ecosystem function, (2) because of the high mobility of nitrate in surface and groundwater, and (3) because of the widespread use of nitrogen in modern agriculture. Annual application of fertilizer-N in the U.S. has grown from a negligible amount prior to World War II to approximately ten million metric tons of N per year. The impacts of chemical intensive agriculture are a special concern in the U.S. Corn Belt. This region is characterized by intensive row crop agriculture (Figure 1). Non-point source nitrogen loads to surface waters in the region are among the highest in the Mississippi River Basin and are reflected by significantly elevated stream nutrient concentrations. In addition to the potential local impacts on receiving waters in the Corn Belt, nitrogen loads from the region are suspected as a primary source of nitrate contributing to hypoxia in the Gulf of Mexico.

The problem of excess nitrate loads can probably be ameliorated by a combination of in field and off site practices, but the limitations and appropriateness of alternative practices must be considered. Although soil nitrogen transformations involve complex spatial and temporal patterns, nitrogen is transported from cultivated fields primarily by leaching

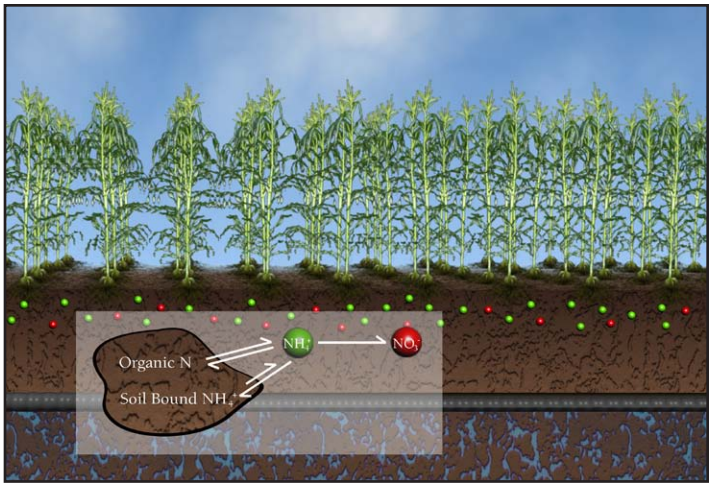

Figure 2. Partial representation of nitrogen transformations in tile drained cropland illustrating nitrate formation by nitrification of ammonium in well drained soil (not all nitrogen transformations are shown).

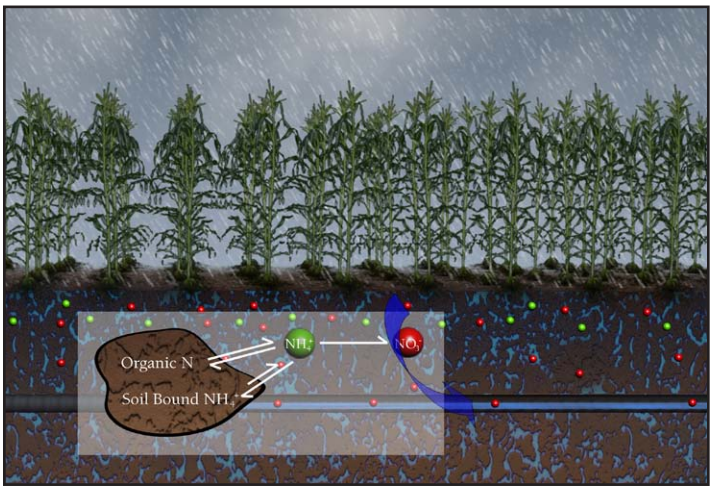

Figure 3. Simplified representation of nitrogen transport in tile drained cropland illustrating nitrate leaching and transport with infiltrating water during a rain event.

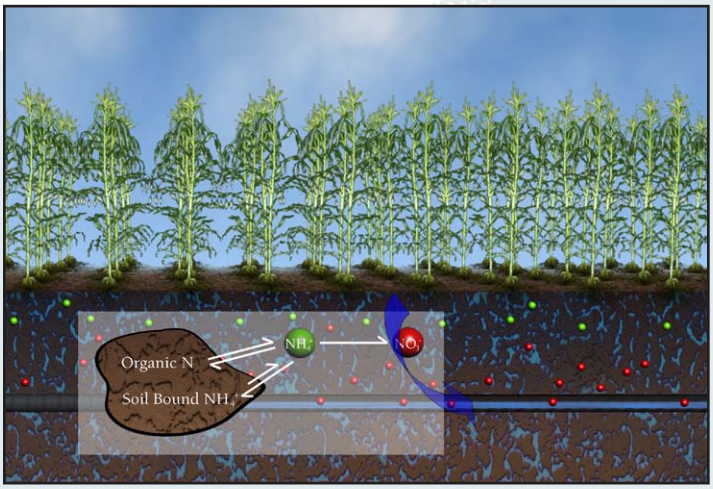

Figure 4. Simplified representation of nitrogen transport in tile drained cropland illustrating continued nitrate leaching and transport with infiltrating water following a rain event.

of nitrate in subsurface flow. In well drained soils, free ammonium not assimilated by organisms is rapidly converted to nitrate by nitrification (Figure 2). This is true whether ammonium is applied in fertilizer or derived from mineralization of organic nitrogen. Whereas ammonium is effectively held by the ion exchange complex in north temperate soils and its movement restricted, nitrate is freely mobile and easily transported with infiltrating water during and after rain events (Figures 3 and 4). Much of the Corn Belt is underlain by networks of subsurface drainage tile (Figure 5) and these provide the primary pathway of nitrogen transport to streams in tile drained landscapes. Grass buffer strips, woody riparian buffers, and other practices suited to surface runoff have little opportunity to intercept nitrate loads in these areas. In contrast, wetlands sited to intercept tile drainage have significant capacity to reduce downstream nitrate loads. From a watershed perspective, this can be thought of as coupling nitrification reactions in aerobic, upland soils with denitrification reactions in anaerobic, wetland soils (Figure 6).

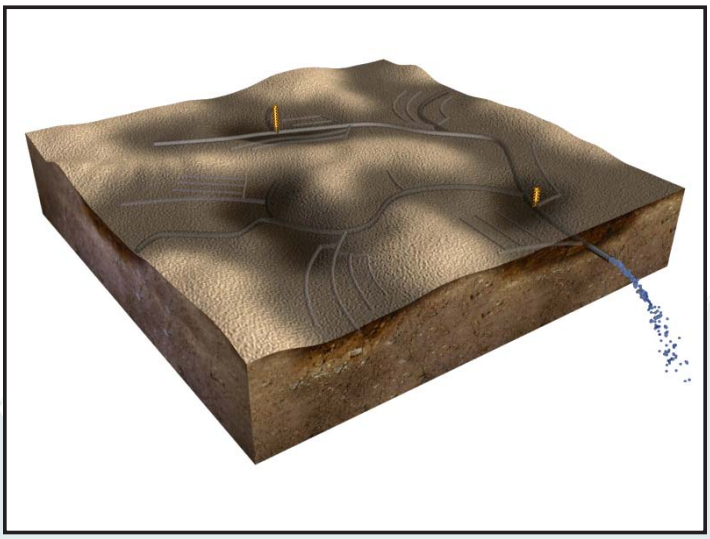

Figure 5. Illustration of tile drainage for a typical agricultural landscape of the western Corn Belt in Central Iowa.

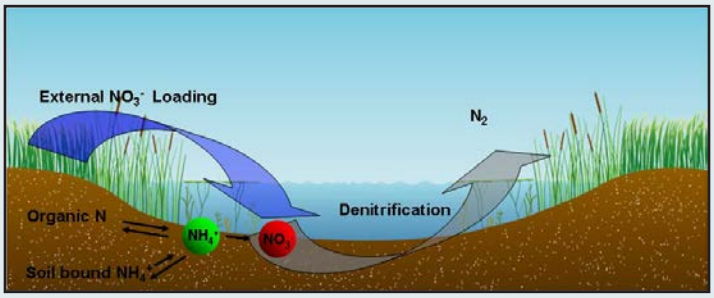

Figure 6. Simplified representation of nitrogen transformations in wetlands illustrating the increased importance of denitrification in wetlands receiving significant external nitrate loads (not all transformations are shown).

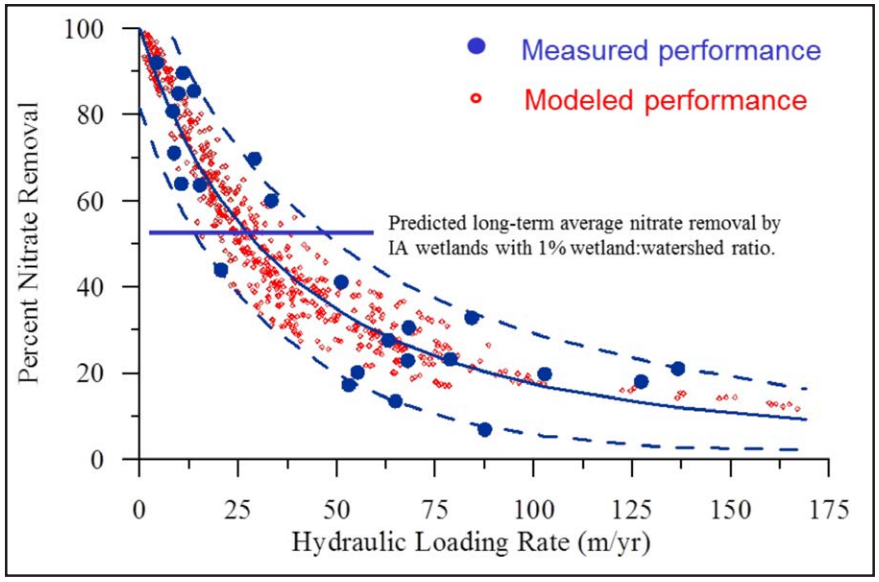

Figure 7. Measured and modeled percent nitrate removal by IA wetlands as function of hydraulic loading rate.

Wetland restoration is a particularly promising approach for heavily tile drained areas like the Corn Belt. This region was historically rich in wetlands, and in many areas, farming was made possible only as a result of extensive drainage. There are opportunities for wetland restoration throughout the region and considerable potential for restored wetlands to intercept nitrate transported in tile flow. Over the past 15 years, our research group has worked on siting, design and assessment of wetland restorations in agricultural watersheds. This work elucidated many of the benefits and limitations of wetland restorations in tile drained landscapes and provided the research foundation for targeted wetland restorations through the Iowa Conservation Reserve Enhancement Program. The Iowa CREP was created by the Iowa Department of Agriculture and Land Stewardship, in partnership with USDA as a targeted, performance based strategy for nitrate reduction in tile drained landscapes. The program provides incentives to landowners to voluntarily establish wetlands strategically located and designed to remove nitrate from tile-drainage water from cropland areas. As an integral part of the Iowa CREP, representative wetlands are monitored each year to document nitrate reduction. By design, the wetlands selected for monitoring span the 0.5% - 2% wetland/watershed area ratio range approved for Iowa CREP wetlands. The wetlands also span a range in average nitrate-N concentration from less than 10 mg/l (parts per million) to approximately 30 mg/l. The wetlands thus provide a broad spectrum of those factors most affecting wetland performance: hydraulic loading rate, residence time, and nutrient concentration. Hydraulic loading rate is the total volume of inflow divided by wetland area and is thus a function of flow and the ratio of wetland:watershed area. Percent nitrogen removal by wetlands is strongly dependent on hydraulic loading rate (Figure 7) and in combination with concentration explains most of the variability in mass nitrogen removed.

This region was historically rich in wetlands, and in many areas, farming was made possible only as a result of extensive drainage.

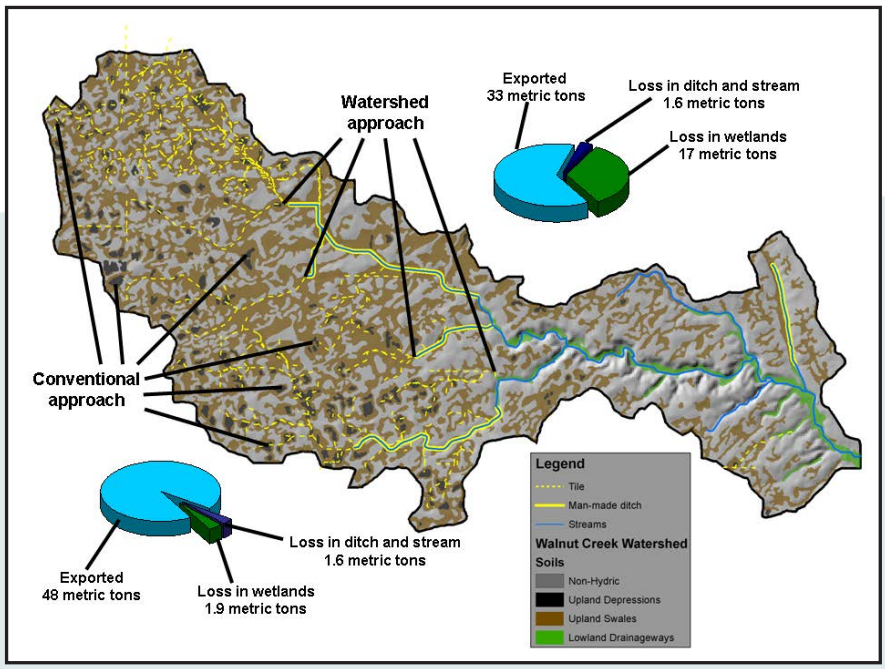

Figure 8. Modeled nitrate mass balance for Walnut Creek watershed with wetland restorations in different landscape positions.

Results demonstrate that wetlands can be extremely effective in reducing nutrient loads in agricultural watersheds, but only if they are appropriately positioned and designed to achieve that function. The effectiveness of wetlands for water quality improvement depends

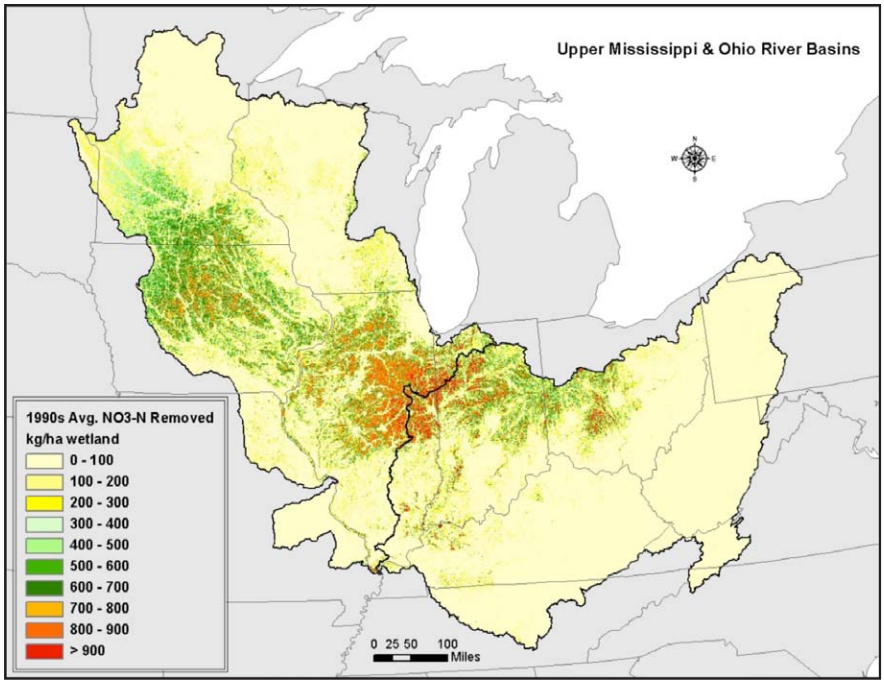

Figure 9. Estimated average nitrate removal in kg N ha-1 of wetland year-1 for targeted wetland restorations in Upper Mississippi and Ohio River basins.

first on the wetlands intercepting a significant fraction of the nutrient load and second on the wetlands being large enough to adequately treat the load they receive. If wetland restoration is to be effective in reducing nitrate loads at the watershed scale, the wetlands must be restored in appropriate landscape positions (Figure 8).

How much could nitrate loads be reduced if wetland filters were established on tile drainage systems throughout the Upper Mississippi River Basin? As part of an ongoing project, we are using performance forecast modeling to estimate the total nitrate reduction that could be achieved by strategically restoring wetlands in tile-drained regions across the upper Midwest. This is based on estimating nitrate loading for different areas of the Corn Belt as well as the potential performance of restored wetlands in those areas. Results suggest more than a fivefold range in mass nitrate removal per acre of wetland restored for different areas of the region (Figure 9). By strategically targeting restoration efforts, a 30% reduction in the total nitrate load exported from the UMR and Ohio River basins could be achieved with approximately 250,000 ha (617,763 acres) of wetland restoration.

VOLUNTEER WATER MONITORING

Erwin E. Klaas
Professor Emeritus of Animal Ecology

The Iowa Geological and Water Survey Section of the Iowa Department of Natural Resources (DNR) is responsible for the design, implementation and management of Iowa's Ambient Water Monitoring and Assessment Program. According to the DNR's website, www.iowadnr.gov, the purpose of the program is to develop and deliver consistent, unbiased information about the condition of Iowa's surface and groundwater resources so that decisions regarding the development, management and protection of these resources may be improved. Monitoring is done by DNR employees or through contracts with researchers at Iowa universities. However, the state does not provide the funding to hire enough staff to monitor all of the lakes, beaches, and streams on a continual basis.

In May 1998, the Survey organized a volunteer monitoring program, called IOWATER, to widen the scope of monitoring across the state. IOWATER's mission is "to protect and improve Iowa's water quality by raising citizen awareness about Iowa's watersheds, supporting and encouraging the growth and networking of Iowa's volunteer water monitoring communities, and promoting water monitoring activities as a means of assessing and understanding Iowa's aquatic resources. Although the protocols for volunteer monitoring are not as rigid as those used for the Ambient Water Monitoring Program, volunteers must attend training classes and use field testing equipment and reagents provided by the IOWATER program.

The Squaw Creek Watershed Coalition was organized in 2001. Members of the coalition and I began sampling water under the IOWATER program soon after. I received training from the DNR in the fall of 2001 and collected my first samples on November 15 from Squaw Creek near the 4th Street and Duff Avenue bridges in Ames. I have continued to collect samples every month except when the creek is completely ice covered. Following IOWATER protocols, I measure air and water temperature, water clarity, pH, nitrite, nitrate, dissolved oxygen, chloride, and phosphate. I also make notes on cloud cover, water levels, human and animal use, and any unusual changes to the stream. Once or twice a year, I survey the stream bed for the presence of aquatic macro-invertebrates such as insects, crayfish, worms, mussels, and snails. Adjacent and upstream land use is also monitored annually.

> To protect and improve Iowa's water quality by raising citizen awareness about Iowa's watersheds, supporting and encouraging the growth and networking of Iowa's volunteer water monitoring communities, and promoting water monitoring activities as a means of assessing and understanding Iowa's aquatic resources.

In 2003, I received advanced training to monitor bacteria. Using a sterile pipette, I collect three replicate one-milliliter (ml) samples of water at each site and transfer the sample into a vial of specially prepared media. At home, I transfer each vial of media to a sterile petri dish and place the dishes in an incubator. The incubator is a Styrofoam box with a small light bulb inside and a meat thermometer in the lid. Samples are incubated for 48 hours at 95 degrees Fahrenheit. Colonies of fecal coliform bacteria growing on the media are then counted and recorded. The media is prepared to differentiate between Escherichia coli (appears purple in color) and other fecal coliforms (pink). E. coli occurs in the gut of all warm-blooded animals including humans. E. coli is considered an indicator of pollution but only certain strains of the bacterium are harmful to humans. Possible sources of E. coli in Squaw Creek are wild animals, livestock, and human waste. In two cases, my monitoring of E. coli detected breaks in sanitary sewers. When the breaks were located, the city quickly fixed them.

In 2008, the Squaw Creek Watershed Coalition began snapshot monitoring on a Saturday in May and October. On snapshot days, volunteers visit all of the more than 50 registered sites in the watershed, conduct the usual field testing, and collect water samples that are sent to the University of Iowa's Hygienic Laboratory for bacterial analysis.

Data collected from IOWATER volunteers is posted on the IOWATER web site at www.iowater.net. To find my data on this site, click on "view data" on the drop-down menu under "Database" on the toolbar. Find the line on the page that says "select monitor" and click on my name in the alphabetical list of last names. This will take you directly to my sites. Click on the numbers at the far left side and it will take you to the page where the data can be viewed according to date of the collection. There are data logs for biological, chemical and physical, habitat, and photos. Similarly, you can view data for all the sampling sites in a watershed by selecting the appropriate watershed. Squaw Creek is listed as a watershed with the Hydrological Unit Code (HUC) 10. Anyone interested in becoming a water monitoring volunteer can contact me at eklaas@iastate.edu or any of the IOWATER staff listed on the web site.

SOIL CARBON:

THE KEY TO HIGH SUSTAINABLE PRODUCTIVITY AND GLOBAL CARBON SEQUESTRATION

Richard C. Schultz, University Professor & Thomas M. Isenhart, Associate Professor, Department of Natural Resource Ecology and Management

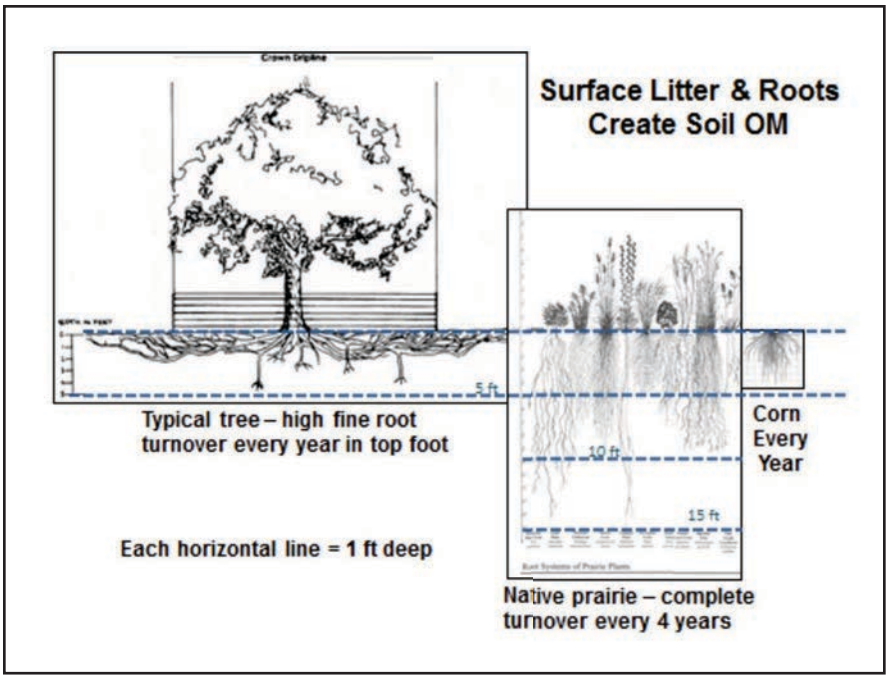

Figure 1. Comparison of root characteristics and depths of trees, native prairie plants and corn. Note vertical distribution common under prairie plants compared to the horizontal distribution common under trees. This difference has a major impact in the distribution of soil carbon in the soil profile.

Soil carbon is the key to Iowa's claim of having some of the world's most productive soils. Undisturbed natural soil is the most complex ecosystem on earth because of its high activity and storage of both living and dead organic matter. Approximately 57% of that organic matter is carbon. Soil carbon is found in the tissues of living plant roots and the millions of microbes, ants, beetles, earthworms, etc. that constitute the living soil ecosystem. It is also present in the fresh litter and stover that falls to the surface and to in the soil as roots die. The decomposition of dead material added to organic matter leaves behind modified and resistant carbon compounds which provide long-term carbon sequestration. Soil organic matter is the key to soil development. Soil develops from inert raw material such as glacial till (the Des Moines Lobe of central Iowa), accumulations of loess (the Loess Hills of western Iowa) or bedrock that has broken into small pieces by natural geologic weathering. Living plants, animals and microbes add organic matter to the inert "parent material" and thoroughly mix them together over long periods of time creating thecomplex medium we call soil.

The distribution of carbon in the soil is influenced by the plant community under which it develops. In undisturbed prairie soils native plant root systems can reach depths of 10-15 feet (Figure 1). These plant rootsystems are completely replaced approximately every four years. This results in organic matter carbon being distributed to great depths providing the deep rich soils that are being farmed in much of the Midwestern United States. In contrast, forest soils are relatively shallow because much of the organic matter is added to surface by the annual leaf drop. As a result, most of the mixing takes place at the surface and fine tree roots arefound in the upper 12-18 inches where most of the nutrients are located. Contrary to popular belief tree roots, even the large structural ones, generally do not go much below three to five feet, but rather spread in all directions around the tree to lengths of at least one tree height (Figure 1).

> Soil carbon is the energy source for soil ecosystems.

Soil carbon is the energy source for soil ecosystems.The decomposition food web is critical to releasing nutrients that are stored in the dead organic matter, but are needed for growth of living plants. The rate of decomposition depends on the kind of organic matter that is available and climatic conditions. Litter produced by conifer forests is slow to decompose because of the com-

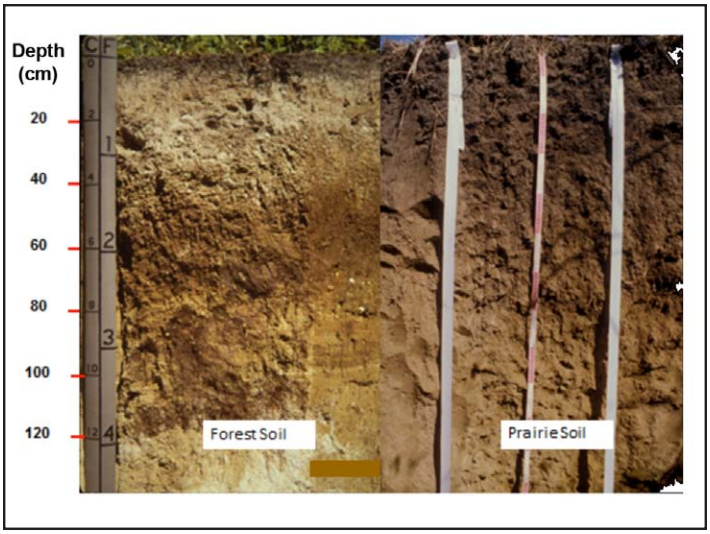

Figure 2. Comparison of forest and prairie soil development. Note the very thin dark layer in the forest soil compared to the much thicker zone in the prairie soil. The darker color is indicative of soil carbon concentrations (source – Jon Sandor, ISU)

plexity of organic matter and the cool and relatively dry soils. Conifer ecosystem productivity can be low because nutrients are locked in the litter. At the other extreme is organic matter that decomposes rapidly in the tropical rain forest where temperatures and moisture are high. In those settings significantly less soil carbon is stored in or on top of the soil and soil nutrients can be rapidly lost when natural plant communities are converted to cultivated crop production.

In the process of decomposition modified and resistant soil organic matter is produced by the organisms. It is this organic matter that is most important in long-term soil carbon sequestration. Some of this carbon can be locked up in the soil for hundreds of years. Soils around the world contain more sequestered carbon than all the carbon in the atmosphere and plants, combined.

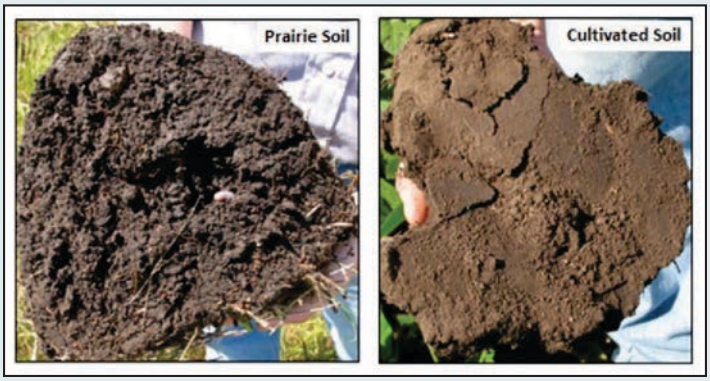

Figure 3. An undisturbed prairie soil (left) from the same soil mapping unit as the cultivated soil on the right. Note the color difference and the lack of porosity and living organic matter in the cultivated soil. Consider the potential difference in water infiltration between these to soils.

Figure 4. Erosion of carbon rich top soil. Notice small gullies, rills, on the hill sides and loss of soil from the field into the adjacent ditch. Significant amounts of this soil and organic carbon can make its way into local water bodies creating major pollution problems. Loss of this soil and organic material reduces the long-term sustainability of crop production and sequestration of carbon for climate change mitigation.

In addition to being an energy source and providing storage for carbon, soil organic matter helps glue mineral soil particles together helping to create soil structure with large pores that are critical for aeration and water infiltration. Soil organic matter itself also acts as a sponge increasing the water holding potential of a soil. These physical actions are very important in maintain a healthy soil ecosystem.

Land-use can have major impacts on soil carbon. When soil is cultivated surface soils are mixed and exposed to more oxygen and warm temperatures resulting in dramatic increases in soil organism activity and decomposition. In addition cultivation breaks down the structure of the soil that was created by soil organisms as they decompose organic matter. The reduction in structure means a reduction in soil porosity which reduces water infiltration potential and aeration (Figure 3). This leads to higher runoff and potential flooding. In the process surface erosion carries both sediment and carbon from hilltops to low spots or to nearby water bodies (Figure 4). Modifying soil tillage by use of minimum or no-till, using rotations that include several years of cover crops, and leaving residue on the fields after harvest can minimize the loss of soil carbon. Soil organic matter is the key to sustainable production and to long-term carbon sequestration. We must carefully manage the fragile fertile soils of Iowa if they are to remain the breadbasket of the world and mitigators of climate change.

RECENT TRENDS IN IOWA STREAMFLOW: 1948-2002

K. J. Franz and Kayla J. Steffens
Department of Geological and Atmospheric Sciences, Iowa State University

In the past century (1906-2005), the average global temperature has risen by nearly 1°C, with the linear warming trend over the last 50 years nearly twice of the previous 100 years (IPCC, 2007). From 1901-1994 there has been an increase in precipitation of approximately 20% across the U.S., largely due to more frequent and intense heavy and extreme precipitation events in recent decades (Todd et al., 2006). Corresponding with increased precipitation, increased streamflow has been observed across the U.S. as well (Lins and Slack, 1999; McCabe and Wolock, 2002). Given the climatic and hydrologic observations across the country, we undertook a study to investigate streamflow trends in Iowa (Steffens and Franz, in review).

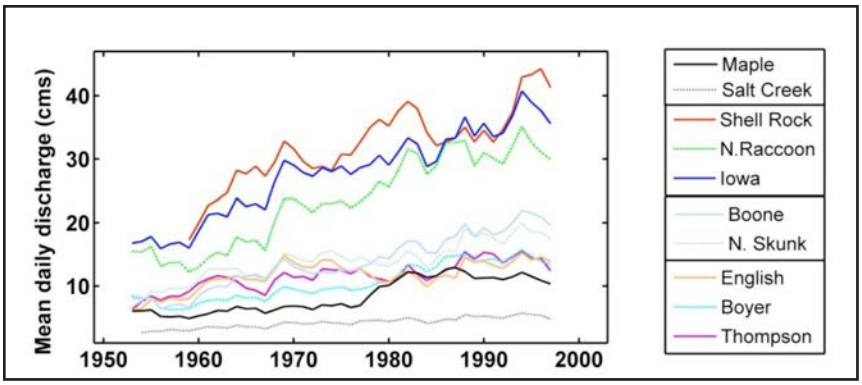

Figure 2: 10-year moving average of mean daily discharge in cubic meters per second for 10 Iowa watersheds.

We chose ten watersheds located throughout the state (Figure 1), ranging in size from 521 km^2 to 4522 km^2 (1 mi^2 = 2.56 km^2). US Geological Survey (USGS) streamflow data from 1948-2003 were obtained for each watershed. Five streamflow variables were analyzed for the presence of increasing or decreasing trends over the study period (Table 1). Summer and winter low flow values were determined for each year by finding the lowest average discharge value for seven consecutive days in the months of May to October and November to April, respectively. A high flow day is a day in which the discharge was larger than the average daily flow plus one standard deviation, and an extreme flow day is one in which the discharge is larger than the average daily flow plus two standard deviations.

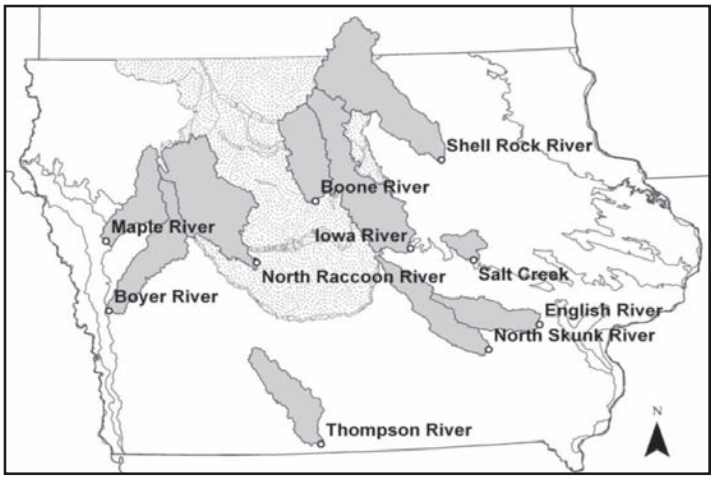

Figure 1: Iowa watersheds used in this study. The Des Moines Lobe is the shaded region in the north central portion of the state.

The annual values were first visually analyzed using plots of the 10-year moving averages. A 10-year moving average takes a ten year window in time and averages the values within the window, starting from the beginning of the record and incrementing by one year until the end of the record is reached. The streamflow values were also tested for the presence of a positive or negative trends using the Mann-Kendall test (MK) (Mann,1945; Kendall, 1975). A significance level of 10% was used, indicating there is a 90% certainty the trend is real and not due to normal variability.

Plots of the 10-year running average of mean daily discharge suggests average discharge is increasing at all sites (Figure 2). The MK test verifies the increasing trend for eight of the ten sites, though the trend was statistically significant for only four basins (Shell Rock, Boone, North Raccoon, and Salt Creek Rivers) (Table 1).

The MK test reveals five sites had a statistically significant negative trend for both winter and summer low

	MK trend (# sites) pos/neg	Statistical significance (# sites) pos/neg
Mean daily discharge	8/2	4/0.0
7-day summer low flow	3/7	1/5
7-day winter low flow	2/8	0/5
High flow days	9/1	5/0
Extreme flow days	3/7	0/1

Table 1: Number of sites with an increasing (pos) or decreasing (neg) Mann-Kendall (MK) trend, the number of sites with a statistically significant trend at a 10% level.

Our discharge analysis suggests, while discharge is increasing in the watersheds, the incidence of extreme flows are not.

flows, and only the North Raccoon River has a statistically significant increase in summer low flows (Table 1). These results are in contrast to other studies, which found significant upwards trends in low flows in the Midwest (Douglas et al., 2000; Schilling and Libra, 2003; Lins and Slack, 2005; Novotny and Stefan, 2006; Juckem et al., 2008).

The MK test also reveals an increase in the number of high flow days for all but one site (Thompson River), with five sites being statistically significant (Boone, Maple, North Raccoon, Iowa and Salt Creek Rivers) (Table 1). Only three sites (Boone River, Maple River, and North Raccoon Rivers) have an increasing trend in the number of extreme flow days per year, none of which were statistically significant. The decrease in extreme flow days was significant for the Thompson River, the southern-most basin studied (Table 1).

Our discharge analysis suggests, while discharge is increasing in the watersheds, the incidence of extreme flows are not (at least this was unproven by the data used). Similarly, Novotny and Stefan (2007) found more basins in their Minnesota study have increases in the number of high flow days relative to extreme flow days.

The central U.S. has been experiencing more variable summer precipitation and more intense rain events (Takle, 2009); therefore, it is logical that streamflow would be increasing in Iowa. However, several studies have shown increasing precipitation alone does not sufficiently account for the increasing streamflow observed in the Midwest, particularly in agricultural regions (Schilling and Libra, 2003; Juckem et al., 2008). In heavily managed areas, it is difficult to separate the impact of climate change from land use on the watershed processes (Tomer and Schilling, 2009). Shifts in land cover and land management are known to have impacts on the hydrologic response of Midwestern watersheds (Tomer et al., 2005; Jukem et al., 2008), and therefore must be kept in mind when considering the trends observed in Iowa streamflow.

Acknowledgements

Financial support for this work provided by Iowa State University and the University of Iowa's Center for Global and Environmental Research are greatly appreciated.

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"WE WANT TO HELP OUR STREAM..."

Mimi Wagner
Associate Professor of Landscape Architecture, ISU College of Design

Much attention is focused on the condition of Iowa urban streams and water quality. Small streams, such as College Creek in Ames, often serve as play areas for children and form the backbone of community green spaces. This article focuses on one Ames neighborhood and their approach to pollution their yards were contributing to neighboring College Creek. Working with Iowa State University researchers and students, residents constructed stormwater best management practices designed to remove the majority of pollutants from first flush rains coming from their yards.

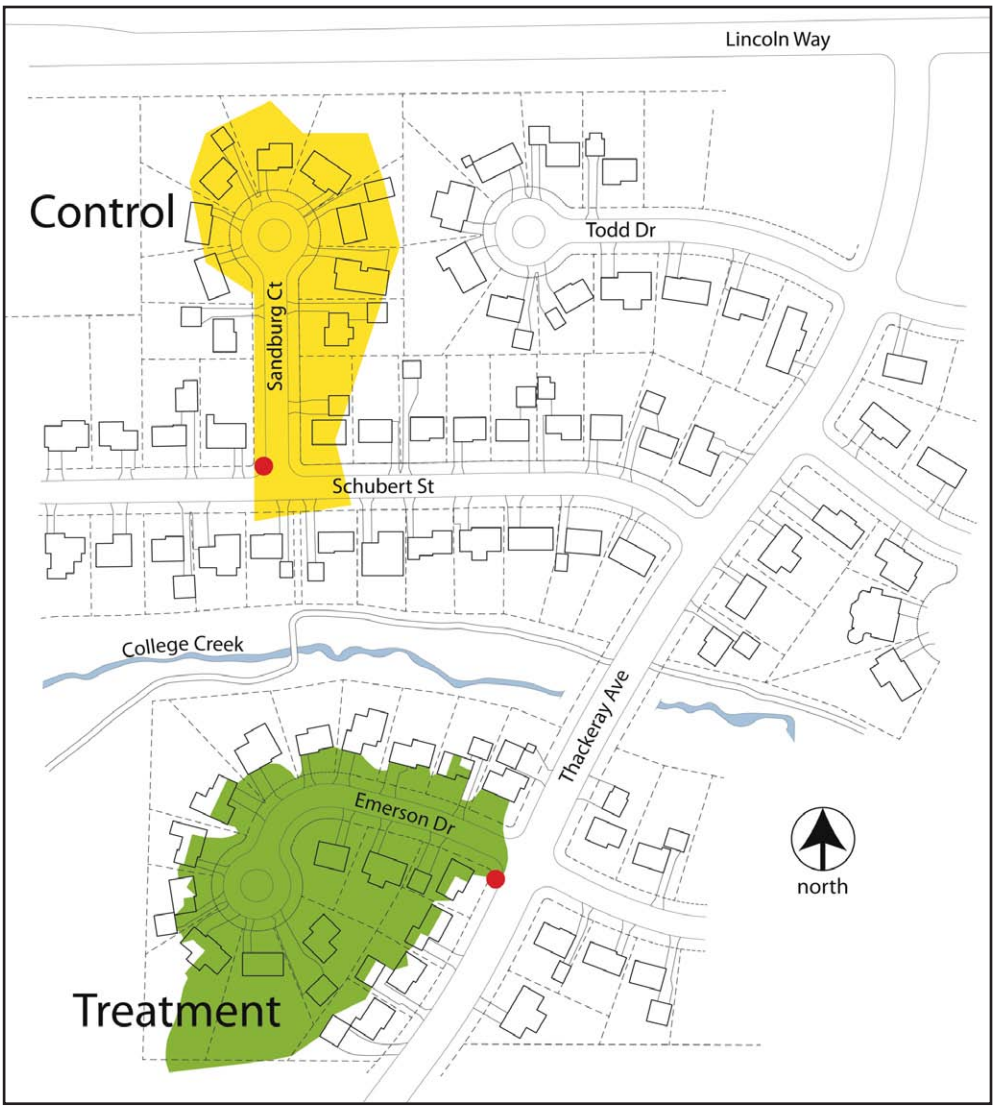


Figure 1. Base map of study site depicting both the stormwater treatment and control areas.

Problem

While the quality of water in streams is a product of runoff from its entire watershed, urban areas, by their nature, are known to consistently contribute certain pollutants. Both volunteer and technical water quality monitoring of Iowa streams, including College Creek, indicate persistently high concentrations of bacteria and nutrients such as nitrogen. Monitoring also indicated that pollutant concentrations tended to increase within urban areas compared with upstream rural portions of the watershed. The sheer volume of stormwater generated by urban streets and roofs also negatively impacts stream condition and water quality. Faced with these results, residents of Emerson Drive cul-de-sac in Ames (Figure 1) agreed to coordinate construction of stormwater treatment practices in their yards in order to filter stormwater runoff from their roofs and yards before entering the storm drain system leading to College Creek.

What They Did

The goal of this community-university research effort was to capture and treat the first 1.25 inches of rainfall occurring in a given storm, eliminating this drainage reaching the storm drain system. Iowa State University's Landscape Architecture Department coordinated with

Figure 2. Bioretention cell under construction in homeowner's yard.

Figure 3. Completed and planted bioretention cell on Emerson Drive.

homeowners to both construct the bioretention cells used to treat the stormwater, as well as to measure the amount of water leaving their cul-de-sac before and after construction. Faculty and students first installed flow meters in the storm drain pipe draining the cul-de-sac one year before construction began. Flow meters continuously monitor and record the amount of water flowing through the pipe. A second flow meter was installed in a similar adjacent cul-de-sac and used as the "control" area where no stormwater practices were installed.

Residents and students constructed 18 bioretention cells on private property. The cells were designed to appear as landscaped areas with local rock and native vegetation. Each cell included a 3' deep excavated hole that was backfilled with an engineered soil mix, planted, edged and mulched. Iowa engineering standards suggest this practice is effective in removing 65-100% of phosphorus, metals and bacteria as well as 30-65% of nitrogen and hydrocarbons from the stormwater they infiltrate. Bioretention cells were positioned in places to intercept the maximum amount of roof, driveway, and lawn drainage. This enabled treatment of as much stormwater as possible while reducing the quantity of stormwater released directly to the stream.

Fourteen of fifteen Emerson Drive homeowners agreed to participate in the project. The average cost of bioretention cell construction was $609, not including labor. Of the total drainage area entering the storm drain system and College Creek, bioretention cells were

constructed to capture and treat 80% of the roof drainage and 54% of lawn areas. The 18 cells constructed totaled 2,128 square feet in size.

How it is working

Post-construction, significantly less stormwater entered College Creek from the Emerson Drive cul-de-sac compared to the control area. Flow meters measured a 70% reduction in stormwater volume reaching the storm drain during the first inch of rainfall compared with the control area (Figure 4). When rainstorms were larger than 1.25 inches, measured stormwater flow was identical between the two sites (Figure 5). As designed, this feature assures homeowners that bioretention cells won't contribute to flooding in the event of large rainstorms, as excess water enters the storm drain system as originally constructed. Importantly, near-record Ames rainfalls in August 2010 did not damage the bioretention cells nor cause flooding.

The Emerson Drive homeowners reported a sense of satisfaction with their contribution to water quality enhancement. They appreciated having "hard data" demonstrating their efforts have paid off in terms of converting stormwater runoff to groundwater infiltration. Homeowners also acknowledged the amount of labor they invested in the bioretention gardens as well as the no-cost aspect of the project to them.

Conclusion

This project provides an important precedent for urban areas and neighborhoods. This project was funded and overseen by the City of Ames Public Works Department and through competitive funds from the Iowa Watershed Improvement Board. Iowa State University provided in-kind professional services. Though this effort was low-cost, we can now demonstrate the benefits that can be derived from homeowners taking action to manage the stormwater their homes and yards produce. We also realize the importance of cooperative efforts between stormwater management professionals, city staff and homeowners.

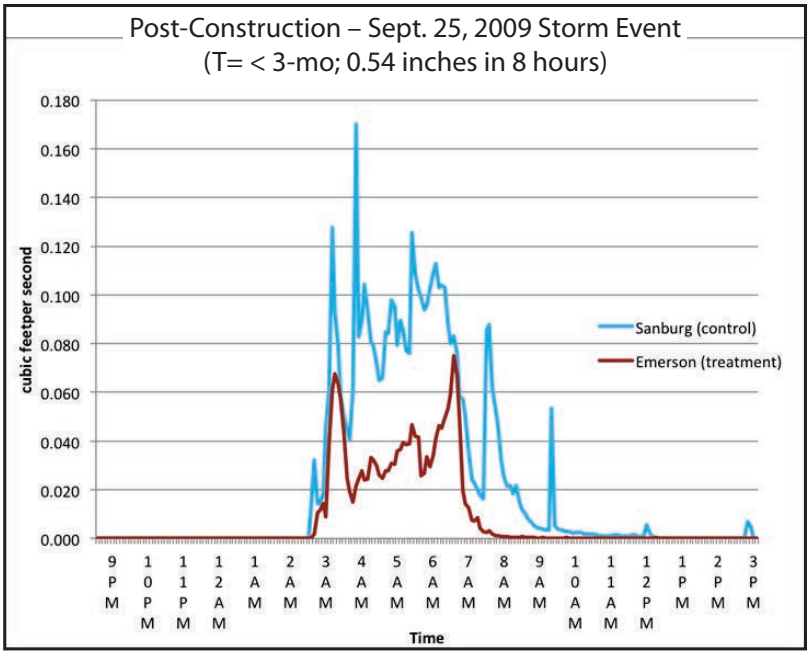


Figure 2. Post-construction stormwater runoff monitoring demonstrated the treatment area (Emerson Drive cul-de-sac show in red) shed far less water than the than the control area (shown in blue) as water was captured in the bioretention cells rather than entering the storm drain system.

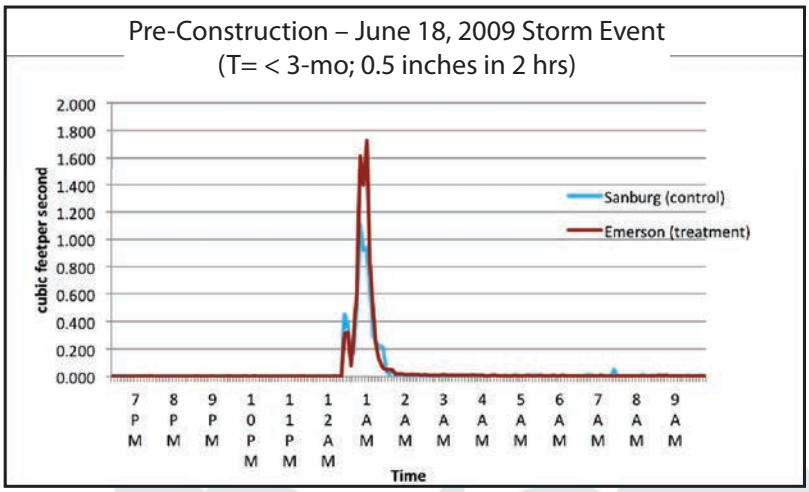


Figure 3. Pre-construction stormwater runoff monitoring indicated the treatment area (Emerson Drive cul-de-sac show in red) shed more water than the control area (shown in blue).

THE EARLY YEARS OF THE IOWA STATE STUDENT CHAPTER OF THE SWCS

Dr. Hugh J. Brown
Field Station Director, Pierce Cedar Creek Institute, Hastings, MI

I was asked to provide some historical perspective for the establishment of the student chapter of the Soil and Water Conservation Society (SWCS) at Iowa State University, but the club started before I joined. For additional background, I contacted Joyce Swartzendruber, NRCS State Conservationist in Montana. She and several other students: Dan Chargo, Stephanie Wald, and Don Wysocki (now Assoc. Professor at Oregon State University's Columbia Basin Agricultural Research Center and Western Board Member of SWCS) organized the club in 1982. They were assisted by Tim Kautza (a former SWCS staff member) and Tom Colvin, (retired from the Agricultural Engineering Dept. at ISU). One of their first projects was to offer soil testing for lawns and gardens as a means of outreach to landowners in the Ames area. I remember performing this service in a subdivision where I found about six inches of topsoil over a compacted layer and obtained a firsthand experience in poor soil management.

One activity that has provided a continuing source of funding for the club is the sale of groundwater flow models. The idea came from Cooperative Extension agents in Wisconsin. What really got the ball rolling was an initial order for twenty-five models placed by Eldon Weber, a Soil Conservation Service (now NRCS) employee who also served in the Agricultural Education and Studies Department. Eldon and others used the models as part of instruction of high school teachers (FFA and VocAg) in support of Iowa's 1987 Groundwater Protection Act. One contribution that I made to the activity was to identify Country Plastics, a local manufacturing firm, to build the models (thus providing a high level of quality control). The models have been shipped to many states and countries, providing a visual demonstration of how water and contaminants move through soils and geologic materials.

I served as President of the student chapter and collaborated with other officers including Dr. Alan Blaylock, Agronomy Manager at Agrium Advanced Technologies in Denver CO and recent recipient of the 2010 Agronomic Industry Award (SSSA) and Dr. Fernando Garcia Prechac who is a Dean at the Universidad de la Republica in Montevideo Uruguay. We were all graduate students of Richard Cruse, who I recruited to serve

as advisor for the club. In my last year at ISU, I served as the student member on the Board of Directors and attended the SWCS conferences in Salt Lake City and Edmonton Canada.

After completing my Ph.D. at ISU in 1989, I did a post doc at the University of Vermont and then joined the Natural Resources and Environmental Management Department at Ball State University in Muncie Indiana. After 18 years of teaching and research, I retired from the university to pursue consulting and conservation goals. Today, I continue to be active in the SWCS, in 2009 and I gave presentations on conservation collaborations at the International SWCS meeting and on the history of conservation to the Hoosier Chapter. I am now very involved in the land trust community and published a curriculum guide "Caring for Land Trust Properties" with the Land Trust Alliance (a national advocacy and support organization).

Over my career, I have seen how important it is to form conservation partnerships to implement management practices to save soil and protect water quality.

With the planet's population approaching seven billion people, our resources are being stretched to the limit. Protecting our future productivity and survival will require a dedicated effort on the part of farmers, consumers, government, and non-profit organizations. Over my career, I have seen how important it is to form conservation partnerships to implement management practices to save soil and protect water quality. The Soil and Water Conservation Society and its members are key players in this conservation collaboration. As evidenced by the names above, many of the students associated with the club have gone on to careers that contribute to improved resource management and environmental protection.

THE SOIL SURVEY PROGRAM IN IOWA

Thomas E. Fenton
Professor Emeritus, Agronomy Department, Iowa State University

The soil survey program in the United States began in the late 1890's. The first soil survey in Iowa was of the Dubuque County area. Field work was completed in 1902 and the report was published in 1903. The "life" of a soil survey is estimated to be about 30 years, so all Iowa counties have had multiple surveys.

Beginning in the mid 1960's Iowa began an accelerated effort to map all counties in a short time. The agencies involved were the Soil Conservation Service, Division of Soil Conservation, Iowa State University through the Experiment Station and Cooperative Extension Service and the counties. Costs were shared equally among federal, state, and county.

Most counties were mapped at a scale of 1:15840 (4 inches = 1 mile) on an aerial photo base. Approximately 12 person-years were required to map a 16 township county.

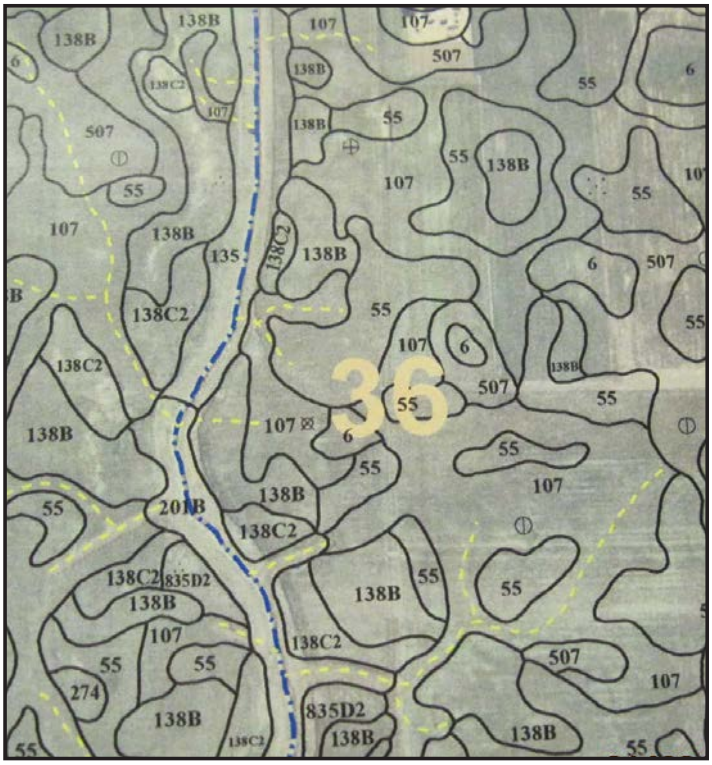


Figure 1. Soil map for Webster County, Iowa.

Soil surveys have gone through many phases over time. Since the initial surveys our knowledge of soils has increased, methods of collecting and presenting data have improved, and the present surveys are more detailed and accurate. However, soil surveys have always followed the same procedures of mapping, classification, correlation, interpretation, and publication.

Mapping - the delineation of soil boundaries on a base map which at the present time is an orthophotograph. A soil map of a section of land is shown in Figure 1. Each polygon on the map is called a delineation and contains a number to identify the soil, a letter to define the slope group, and if needed, a number which identifies the erosion phase-2 for moderately eroded and 3 for severely eroded. If no number is present, the soil erosion phase is none or slight. All delineations containing the same set of symbols is called a map unit, for example 138C2. The number 138 identifies the Clarion soil series. In Iowa, a statewide legend is used to identify soil series and each series has a unique number. The letter C identifies the slope group as 5 to 9 percent, and the number 2 identifies the area as moderately eroded. Other symbols on the map show drainageways and contrasting soil areas which affect soil use but are too small (generally less than 2 acres) to show as a separate delineation. For example, the small circle with a plus sign indicates a wet depression with restricted permeability in a 107 (Webster) delineation in the upper middle of Figure 1.

Classification - the systematic arrangement of soils into groups or categories. The present system of soil classification used throughout the United States and many other countries is Soil Taxonomy. The lowest category in the system is soil series which in the above example is Clarion.

Correlation - a nation-wide process to ensure soil series names are defined and used consistently. For example, a soil named Clarion has the same set of soil properties as a result of the impact of a particular set of soil-forming factors wherever the Clarion name is used.

Interpretation - the prediction of soil behavior for specific uses or management based on inferences from soil properties. They may be either qualitative or quantitative estimates of soil behavior.

Publication - Compilation of soil information of a survey area including the descriptions, properties, classification, interpretations, and maps. The publications are available in hard copy and digital format. In the near future, they will be available only in digital format at: http://soildatamart.nrcs.usda.gov/state.aspx

Additional soil and land use information, plus a statewide soil data base called the Iowa Soil and Interpretations Database (ISPAID) are available at http://extension.agron.iastate.edu/soils/

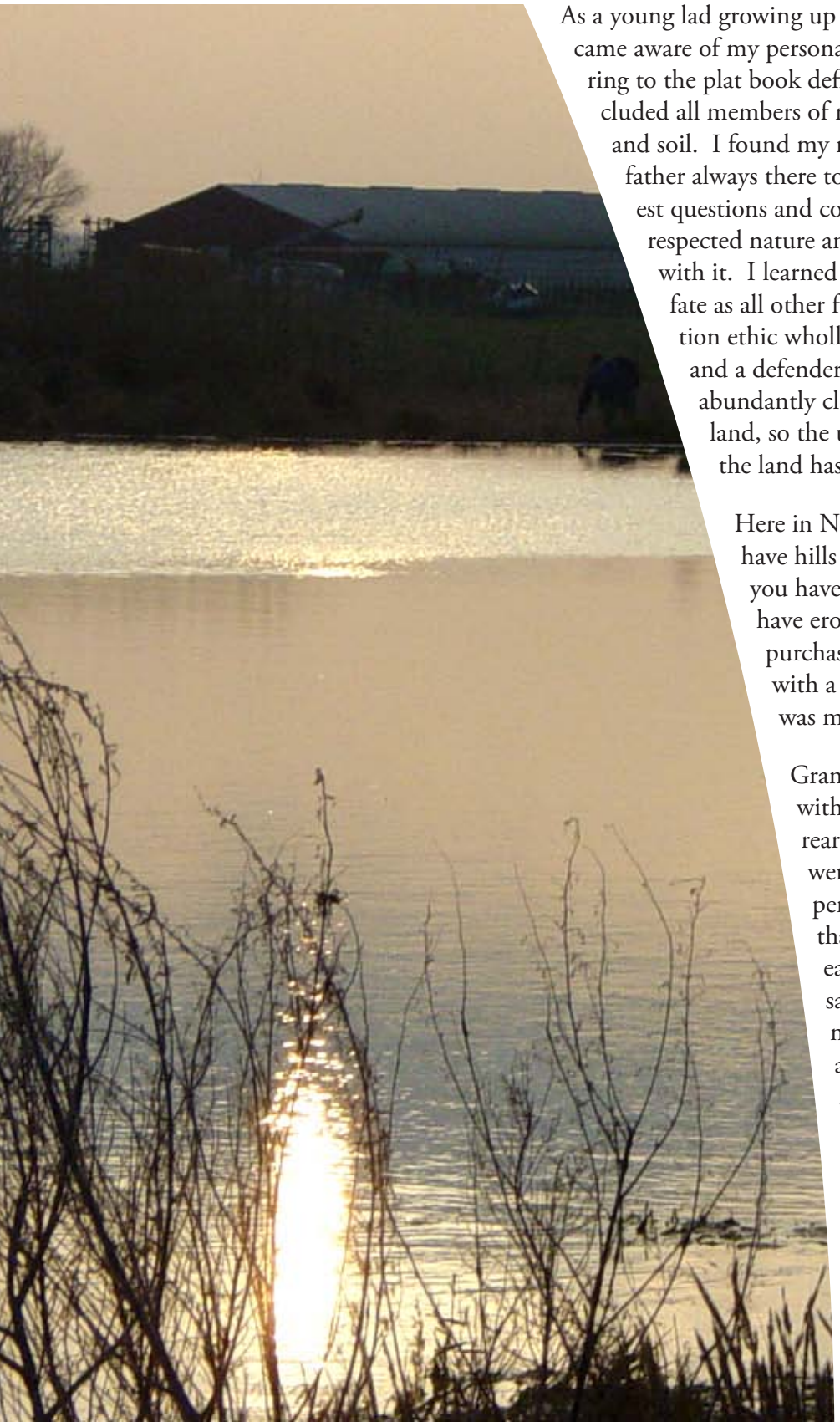
Approximately 12 person-years were required to map a 16 township county.

A great advance in contributing to improvement of soil surveys was the use of aerial photographs. They came into common usage in the late 1930's. Their use greatly increased the precision with which soil boundaries could be delineated on soil maps. Another important variable is the scale at which the soil map is made. Early surveys were made at a scale of one inch per mile. Beginning in the late 1950's and continuing until 1990, the most common scale of mapping was 4 inches per mile. Since 1990, the scale used is 5.28 inches per mile.

Understanding of soils, their development, and properties is based on knowledge of the five classic factors of soil formation-climate, organisms, topography, parent material, and time. Because of intensive use of the soil, human activity is considered by many to be a sixth soil forming factor. The need for updates of soil surveys will continue as our knowledge of the interactions of the above factors continues to increase with introduction of new technologies including improved remote sensing techniques, Light Detection And Ranging (LiDAR), smart phones, and many other innovations.

AN AFFAIR WITH OUR LAND

Richard Jensen
Soil Commissioner of Fayette County, Iowa



As a young lad growing up on a farm, 70 and more years ago, I became aware of my personal reverence for the land. I am not referring to the plat book definition of the land; my boundaries included all members of nature's community: water, plants, animals and soil. I found my rootage and citizenship so natural, with my father always there to give definition and meaning to my deepest questions and concerns. He was an ordinary man who respected nature and understood how to live in harmony with it. I learned very early in life that man shares the same fate as all other fellow land members. With this conservation ethic wholly accepted, I grew to become a respecter and a defender of my complex community. It became abundantly clear that it is wrong to bring poverty to the land, so the user can achieve a profit. My affection for the land has never abandoned me.

Here in Northeast Iowa, we have hills. Where you have hills you have ditches; where you have ditches you have plows, and when they are combined you have erosion. In the early 1940s, my grandfather purchased his first tractor, a Minneapolis Moline with a two bottom plow. Nearly every farmer was moving from horse power to gas power.

Grandfather's new tractor wasn't equipped with fenders, which would have covered those rear steel wheels. For traction, the wheels were lined with sharp steel lugs that would penetrate into the ground. It also had a seat that could be swung from right to left for easy viewing ahead. Very little operator safety was designed into his new, modern machine. I am sure he sat on that seat with a proud grin that farmers today can still identify with. That unfortunately was about to be replaced with cries of pain and agony.

On an early spring morning he climbed onto his new machine and went to the field to "plow in the ditches," a common and accepted practice of filling an eroded

out ditch with soil by plowing in the edges, until the ditch is filled with new soil. The effects of this practice were temporary at best as it always eroded away again, somewhat like putting more firewood in a stove after the fire has consumed the previous fill. The wood goes up in smoke and the soil goes down the nearest river. The problem is that wood is a renewable resource, while the soil is not. The land is left impoverished and depleted of nutrients used to grow healthy plants.

What was he thinking as he steered his iron horse along the unstable, soft side of that ditch? Were his thoughts of losing soil, conservation or proper land treatment? Though he loved his farm, I doubt it. His purpose and objective was to fill in the ditch in order to produce another corn crop. He was in strictly an economic mode and felt little or no obligation to the land. Then suddenly, one wheel dropped over the side of the ditch; the seat slid violently over on to the moving wheel. Grandpa was grabbed by the lugs and pulled under the wheel and crushed into the ground. With a mangled hip and a broken, bleeding leg, he watched as his new tractor and plow continued a short distance, as the tractor met its fate rolling over into the steep ditch.

I have witnessed the assault on the land all my life; seeing impaired waterways, abused forests, eroded soils and disappearing wildlife.

Grandma was not tolerant of folks who showed up late for dinner, no excuse was acceptable and everyone respected that rule. When Grandpa did not show up for dinner she went to see why. She found him barely alive.

The rest of the story is of the grief, sorrow and misery he endured until his death. It was not easy in those days to farm with an artificial leg. Without total physical abilities, Grandpa's farm was crippled and threatened with financial failure. Hospitalized for ten months and a full-time hired man to pay were a few of the consequences of that unforgettable day. After several years of struggle and defeat, I was given the opportunity to "take over." My story is written in honor and memory of them; although I do not believe they would approve of my sharing.

Many changes have occurred in the last 60 years. The tractors are safer and artificial limbs enable the user more comfort and the opportunity to lead a normal life. Technology has benefited and enlightened our lives tremendously. New inventions, tools and methods have enabled farmers to make changes to the landscape of unprecedented violence, rapidity and scope. The result is less food and fiber producers operating the land, more humans reaching out to fill their stomachs, and at the same time, plundering the shrinking planet of vanishing natural resources.

To make matters ever worse, each generation of children are more disconnected from nature than ever before. This separation from the land is detrimental to the wholesome development of our kids. They have been "high jacked" by the artificially synthetic virtual world of amusement and now lack opportunity or desire to go outdoors. Without interactive exposure to the awesome natural world, they won't develop a loving relationship with the earth. These future decision makers will determine the fate of our forests and open lands, our lakes and streams, our parks and agricultural lands. A simple truth is that we only take care of things we love and understand.

I have witnessed the assault on the land all my life; seeing impaired waterways, abused forests, eroded soils and disappearing wildlife. We are more production orientated than ever before, but it is primarily for economic benefit. We have more government regulation in wide forms of conservation management efforts that pay farmers for decent land care behavior. Technology has lulled us all into a false sense of security; given time, more gadgets and gismos will enable mankind a substitute for a healthy environment. Anyway you look at it, our landscape cannot wait patiently for aid and comfort.

Could it be that my Grandfather's accident holds some clue as to how we should treat the land? Are we all on a perilous road with disastrous results brought about due to our apathy and detachment from the life giving land? Do we need more fathers who illuminate for children the truth that the land should not suffer poverty for man to profit? I hope someday soon, we come to the understanding that all life on earth shares the same fate.

DRAINAGE WATER MANAGEMENT FOR REDUCING NITRATE LOSSES FROM TILE DRAINED FIELDS

Dan B. Jaynes, Soil Scientist
Rob Malone, Agricultural Engineer, USDA-ARS
Kelly Thorp, Agricultural Engineer, USDA-ARS

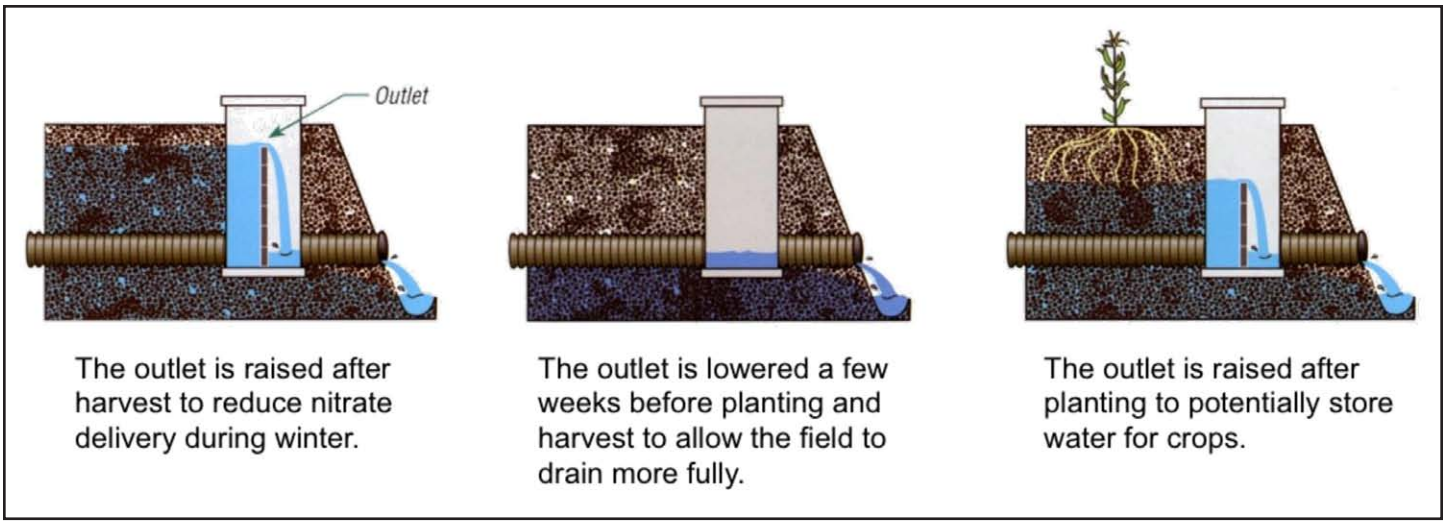


Figure 1. Schematic of a drainage water management control structure. In the winter the water table is raised to conserve water and nitrate that may be dissolved in it (left). In the spring before planting and in the fall before harvest, the water table is lowered to allow for field operations (middle). In the summer, the water table can be partially raised to prevent over drainage and retain some water (and nutrients) for the growing crop. After Frankenberger et al.[7]

Excessive nitrate in surface waters increases the cost of water treatment for domestic use and each summer drives the formation of a hypoxic or low oxygen zone in the Northern Gulf of Mexico. Much of the nitrate in surface waters comes from artificially drained row crop land in the Midwest. There are over 7.8 million acres of drained lands in Iowa alone with an additional 43.8 million acres in the Midwest[1]. Research in Iowa and surrounding states over the past 10 years has clearly demonstrated nitrogen fertilizer management alone cannot reduce nitrate losses from drained fields sufficiently to meet water quality goals[2], thus additional methods to reduce nitrate losses are needed. Drainage water management (DWM) is a promising technology for reducing nitrate losses from artificially drained fields. While there is an extensive history for the practice in North Carolina, little is known about the efficacy or cost effectiveness of the practice under Midwest conditions.

> If DWM were adopted on all of this land, nitrate losses in tile drainage could be reduced by approximately 83 million kg/yr.

DWM differs from conventional free artificial drainage in that a control structure such as a flashboard riser is installed at the drainage outlet (Fig 1) allowing the farmer to manage the field's drainage. By setting the elevation of the riser, the depth of the water table can be adjusted whenever drainage is occurring. When using DWM, the drain outlet is typically set just below the soil surface during the winter or off-season when a high water table within the field would not hinder agricultural activity or crop growth. During planting and harvesting, the outlet is set to the depth of the tile drain to give maximum drainage for good trafficability and seed bed tilth. The option also exists to manage the water table during the growing season by raising the outlet within a few feet of the surface to retain some water in the field which would otherwise drain and have the water available for crop uptake – potentially increasing crop yields. DWM is best suited for fields that are flat, with slopes less than 0.5%. Therefore, a control structure can control the

Table 1. Annual and 4-yr average mass loss by drainage treatment and F statistic for individual year and 4-yr average comparisons.

Year	2006	2007	2008	2009	4-yr sum
Crop	corn	soybean	corn	soybean	all
Treatment	kg ha^{-1}				
CNV	27.6	52.3	45.6	16.0	137.2
DWM	20.5	30.5	35.1	13.2	95.6
DWM-CNV	-7.1	-21.8	-10.5	-2.8	-41.6*

significant at P=0.05

Table 2. Average crop yield for conventional, CNV, and drainage water management, DWM, for 2006–2009 and the F statistic for the within year comparisons.

Year	2006	2007	2008	2009
Crop	corn	soybean	corn	soybean
Treatment	bu ac^{-1}			
CNV	165.0	55.6	211.3	56.3
DWM	174.2	62.2	210.9	60.0
DWM-CNV	9.2	6.6	-0.4	3.7

significant at P=0.05

water table within 1 or 2 feet of elevation for at least 20 acres and where pattern drainage systems have been installed.

In earlier studies, DWM has been found to primarily reduce the annual amount of water discharged at the drain outlet[3] rather than lower the concentration of nitrate in the drainage. The reduction in discharge also reduces the loss of agricultural chemicals such as nitrate dissolved in the water. Reductions observed outside of the Midwest have ranged

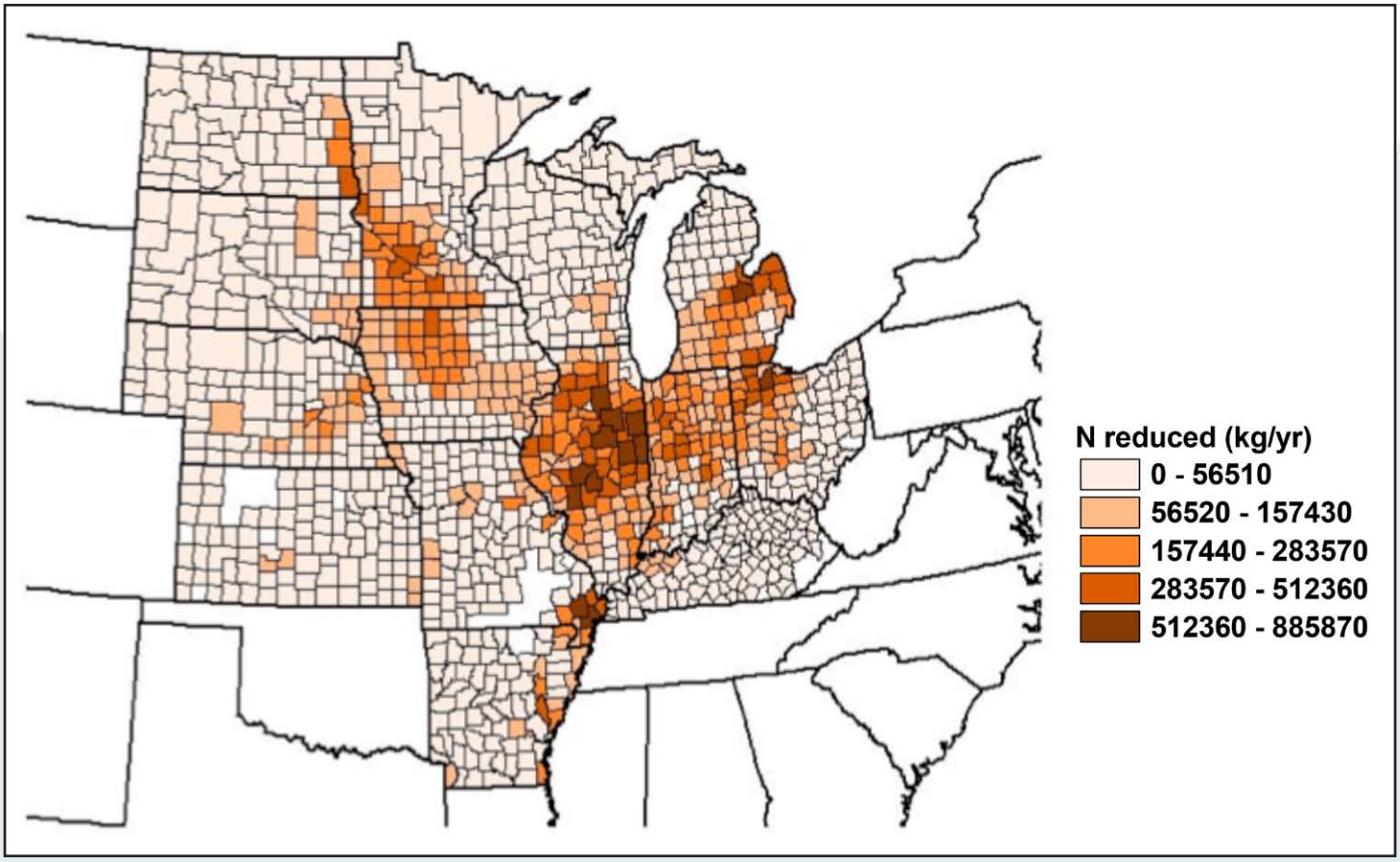


Figure 2. Reduction in nitrate losses from artificial drainage if Drainage Water Management is installed on all suitable corn ground. From Jaynes et al.[5]

from 30 to 50%[3], and it has been estimated that DWM is being used on as much as 1.98 million acres in the U.S.[3]. However, little is known of the potential for this practice to reduce nitrate contamination of Midwest Rivers.

With the support of an NRCS Conservation Innovation Grant, the effectiveness of DWM is being investigated across Ohio, Indiana, Illinois, Minnesota, and Iowa. Results from one Iowa farmer's field with parallel tiles with and without control structures illustrate the potential benefits of DWM. The nitrate losses in the tiles using DWM were numerically lower than in conventionally drained tiles in every year (Table 1). The differences were not statistically significant (P = 0.05) in any year, but across all four years DWM significantly reduced nitrate losses in tile drainage by more than 40 kg/hectacre compared to conventional drainage.

Average crop yields for each drainage treatment are shown in Table 2 for 2006-2009. Average yields for the DWM treatment were higher in 2006, 2007, and 2009 than for the conventional drainage (CNV). However, only in the soybean years (2007 and 2009) were the yield differences by drainage significant (P = 0.05). In 2008, DWM actually resulted in about a half a bushel per acre lower yield on average than CNV drainage. Relatively wet weather during the 2008 growing season may have negated any advantage DWM would have had for conserving water.

Based on these results and previous field studies, we have investigated the water quality potential for DWM if widely adopted across the Midwest[4, 5] Using the comprehensive agronomic model Root Zone Water Quality Model, we estimated the potential for DWM to reduce nitrate in streams across the range of climate and agronomic practices of the Midwest. Using STATSGO soils data and the National Land Cover Database land cover information, we showed DWM might be suitable on about 4.8 million hectacres (11.5 million acres) of land used to grow corn within the Midwest. If DWM were adopted on all of this land, nitrate losses in tile drainage could be reduced by approximately 83 million kg/yr (182.6 million lbs/yr) (Fig. 2). For comparison the entire Mississippi River transports about 813 million kg (1789 lb) of nitrate each year[6] so while DWM could potentially remove a sizeable amount of the annual nitrate load, it would be only a fraction of the load being transported by the Mississippi River.

Drainage water management appears to be a viable practice of reducing nitrate losses from field tiles entering surface waters in the Midwest in some landscapes. However, research to date does not show a sufficient yield benefit to warrant by itself adoption by farmers. Wide spread adoption of the practice for water quality improvements will only result if the practice is cost shared using public monies. DWM is currently part of the cost share program for the USDA's Mississippi River Basin Healthy Watersheds Initiative which should help spur the installation of the practice across the Midwest.

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VISIBLE AND INVISIBLE CAUSES FOR SOIL EROSION IN NORTHEAST CHINA

Xiangwei Chen & Enhen Wang

China experiences serious soil erosion due to its complex diverse topography across the 9,600,000 km^2 (3,700,000 mi^2) of its mainland (slightly smaller than the U.S.) and pressure brought on by its high population - more than 1.3 billion citizens. According to the U.S. soil classification system, the Black Soil (Mollisol - similar to most Iowa soils) region of Northeast China includes 185,100 km^2 (72,200 mi^2) in Heilongjiang Province, 57,700 km^2 (22,500.5 mi^2) in Jilin Province, 45,500 km^2 (17,700 mi^2) in the eastern part of Inner Mongolian Province, and 14,600 km^2 (4,700 mi$^{2)}$ in Liaoning Province (Liu & Zhang, 2006).

As the most important commodity grain production base of China, the Black Soil region of Northeast China is suffering water runoff and unsustainable soil loss annually. The area in black soil region experiencing heavy soil erosion approached 276,000 km^2 (107,812 mi^2) in 2010 with water erosion heavily impacting an area of 180,000 km^2 (70,312 mi^2), freeze/thaw erosion impacting an area of 62,000 km^2 (24,219 mi^2), and wind erosion impacting an area of 34,000 km^2 (13,281 mi^2). Approximately 460,000 erosion created gullies have been identified (Chinese Ministry of Water Resources et al., 2010). During the last half century, on average top soil depth has been reduced from approximately 60 – 70 cm (24 – 28 inches) to 20 – 30 cm (8 – 12 inches), organic matter has been reduced from 12% to 2 – 3% , bulk density has increased from 0.79 g·cm-3 to 1.26 g·cm-3. Gulley formation has limited farming on 4,830 km^2 (1,887 mi^2) and soil loss induced crop loss in this area amounts to more than 19,000,000 t yr-1.

The high erosion rate in the Black Soil region of China results from a combination of natural and anthropic factors. The Northeast China landscape is characterized by hills with gentle gradient of 3 – 5° and long slopes of 500 m (1,640 ft) – 1,000 m (3,280 ft), which gives rise to a large erosion potential of 3,000 – 5,000 t·km-2·yr-1 (13 – 22 ton ac-1 yr-1) (Shen et al.,1993). In addition, 75% of the yearly precipitation typically falls in June to August because of the prevailing temperate continental monsoon climate in the Black Soil region. These intensive rainfalls increase soil erosion by 70%, comparing with the rainfalls well distributed throughout the year (Cui et al., 2007). Freeze/thaw cycle induced erosion increases in the

Black Soil area of Northeast China are of great concern. Absence of crop residue on the soil surface in winter increases the frequency and intensity of freeze/thaw cycles, impacting aggregate stability which in turn impacts soil erosion potential from spring rainfall. In this region, the retreat rate of gully heads may reach rates as high as 12 $m \cdot yr^{-1}$ (39.4 ft yr^{-1}) (Hu et al., 2007). Additionally, the nature and properties of black soil in this region also favors elevated soil erosion rates. Black soil in Northeast China is developed from lacustrine deposits, Quaternary Loessial Loam. Higher clay content and lower water conductivity in the subsoil inhibits infiltration and further aggravates the topsoil erosion problems. Where these situations exist the subsoil also has a higher erodibility compared to topsoil (Zhang et al., 2002). This means gullies will develop quickly and the subsoil may be eroded rapidly once the topsoil is lost.

Farmers can use the farm land handed out by the government; however, they are not allowed to trade or sell that land - ever. So the farmers do not care about soil quality in the long run.

Human influence on soil erosion is also critical in the Black Soil region of Northeast China. Setting a variety of obvious factors aside, land ownership is the root of soil erosion in a way. Farmers in China do not own the land they farm. Every square inch of land in China belongs to the nation/government. Farmers can use the farm land handed out by the government; however, they are not allowed to trade or sell that land - ever. So the farmers do not care about soil quality in the long run. They overuse their temporal lands to maximize profits as much as possible. Most farmers still use conventional tillage or some form of conservation tillage, but no farmers have enough land to use no-tillage. They cannot afford to pay for expensive machines and of course they cannot afford the matched no-tillage services, such as weed and insect pest management. Is it fair to say that the Chinese government is blocking development of agriculture and increasing soil erosion potential in black soil region of China? It is too early to judge.

The Chinese government directs Chinese farmers to feed 25% of the world's people while using only 9% of the world's farm land, which would be a great contribution to world food security. Socialist public ownership of land was a very important policy for maintaining public stability at the beginning of modern day China and before China joined World Trade Organization (WTO). More and more agricultural products are allowed to be imported since China's accession to WTO, which in theory should reduce the pressure on land use in China and therefore lower the soil erosion risk. However, it is not yet the right time to encourage Chinese farmers to step into the world market and trade by themselves. In 2008, two thirds of Chinese farmers had less than 8 years of education and still need Chinese government's

protection. Improved policy and economic development is more important than advances in science and technology in China, a socialist state with a population of 1.3 billion.

Farm fields in the Black Soil region in Northeast China are being "cut up and cut off" by numerous gullies; however, Mollisol fields in Iowa are "sewn together" by grass filter strips. The same productive soil resource have different pictures in the world's different hemispheres, but they will have one ultimate fate theoretically — buried in seabed of the world's oceans if not managed more appropriately. We hope the funeral can be stopped, or postponed as long as we possibly can.

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IOWA FLOOD CENTER: LIVING WITH FLOODS

Jackie Hartling Stolze
Editorial Associate, IIHR-Hydroscience & Engineering, University of Iowa

For Iowans, information is the key to being ready for the next flood. The Iowa Flood Center (IFC) at The University of Iowa is working to provide Iowans with accurate, scientific information to help individuals and communities better understand their flood risk.

After the Flood

In the last three years floodwaters have inundated the campuses of both Iowa State University and The University of Iowa.

Research that began even as the waters were rising at The University Iowa was the genesis of the Iowa Flood Center (IFC), the nation's first academic center devoted solely to the study of floods. The IFC was founded in 2009 and resides in the C. Maxwell Stanley Hydraulics Lab, home of IIHR—Hydroscience& Engineering. First-year state appropriations of $1.3 million supported the center's overarching objectives of improved flood monitoring and prediction capabilities in Iowa.

Through collaborations with communities, individuals, government agencies, and decision-makers, the IFC is bringing engineering and scientific expertise to flood-related issues. These new partnerships and prioritiesare one of the most hopeful outcomes of the flood, says IFC Director Witold Krajewski.

> "These maps will provide Iowans with new information concerning flood risk in their own communities."

IFC research depends on the talented students who collaborate with faculty and researchers. Approximately 20 graduate and undergraduate students at the UI and ISU are currently involved in IFC work. These students gain hands-on training and expertise spanning a variety of academic disciplines, thus preparing them for the complex problems of the future.

Krajewski, who is an IIHR research engineer and professor of civil and environmental engineering, says the center is a vital resource for Iowans as they prepare for future floods.

Samples of IFC Research Initiatives:

Among the IFC's current projects are two efforts to develop floodplain maps and a project to place stream sensors on bridges across the state.

Web-Based Flood Inundation Maps

IFC researchers are developing high-resolution web-based flood inundation maps for several communities in Iowa. Data is gathered through bathymetric surveys to determine the shape of the channel from information supplemented by aerial LiDAR. With this data researchers can create very detailed maps of the streambed, which can be used to illustrate the extent of flooding under different flooding conditions.

The information is available to the public via an interactive Google Maps-based online application, so community members can see how predicted flood levels could affect their property. Maps for several Iowa communities are already available at www.iowafloodcenter.org/maps.

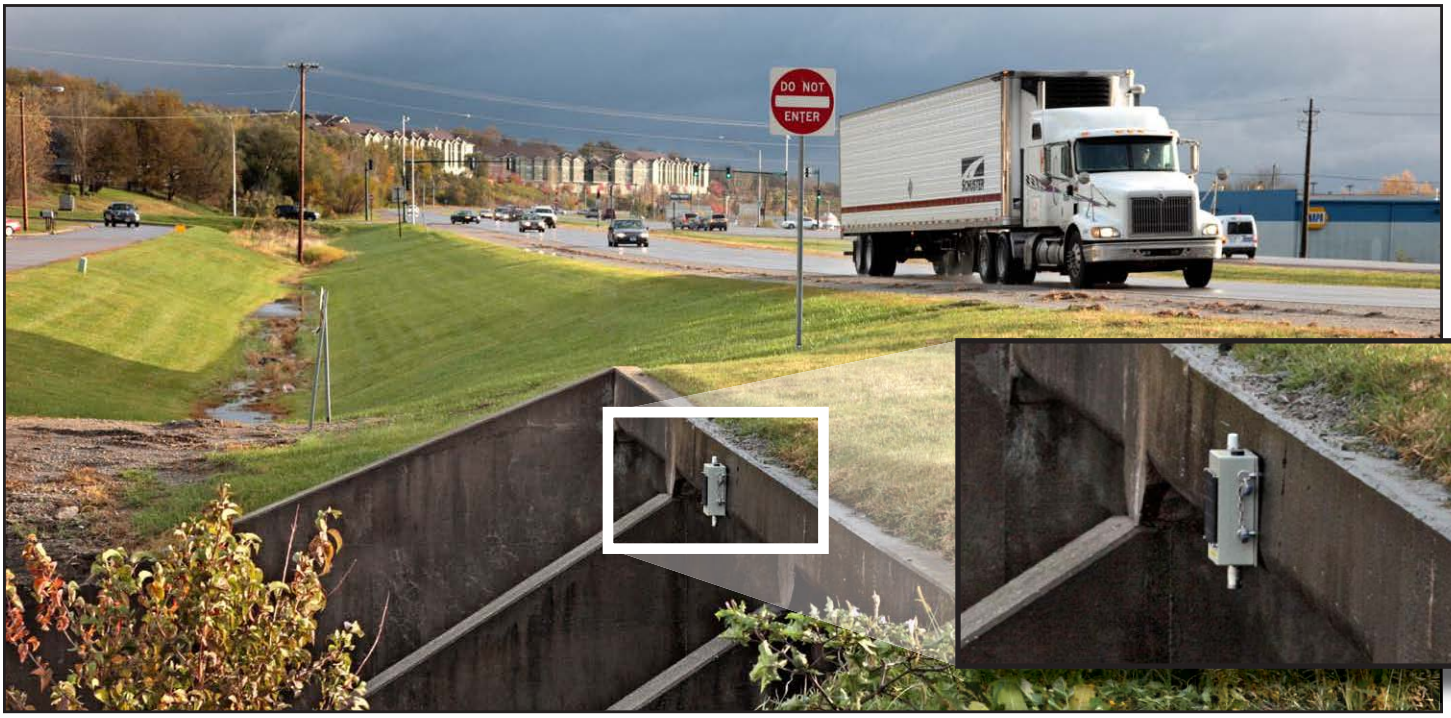

Figure 1. A gauge measuring water levels under a bridge transmits up-to-the-minute data to the Iowa Flood Center.

The Iowa Floodplain Mapping Project

Building on the success of the flood inundation maps, IFC researchers have begun work on a project that will provide less-detailed floodplain maps for most of Iowa. The four-year Iowa Floodplain Mapping project is funded with $10 million from the U.S. Department of Housing and Urban Development. Working closely with the Iowa Department of Natural Resources (DNR), the IFC will develop FEMA-approved floodplain maps for the 85 Iowa counties that were declared federal disaster areas after the 2008 floods.

"These maps will provide Iowans with new information concerning flood risk in their own communities, so they are empowered to make informed land use and land management decisions," says Nathan Young, an IIHR associate research engineer and manager of the project.

IFC researchers will map all streams draining one square mile or more in each of the 85 Iowa counties, relying on statewide LiDAR data recently collected by the DNR. LiDAR is a remote sensing technology used to develop digital elevation models of the land surface. Young says this will make it possible to accurately describe Iowa's river and stream networks, develop computer-based flood simulations, and delineate floodplains. In the process, researchers hope to develop innovative, efficient new floodplain mapping tools. Once completed, the maps will be available online to guide floodplain regulation and management.

Affordable Stream Stage Monitoring

Until recently, gauges to measure river and stream levels were few and far between in Iowa. IFC students aided in the development of an affordable electronic sensor to measure stream levels and transmit up-to-the-minute data to the center. The sensor is placed on bridges and uses sonar to measure the distance from the water's surface to the sensor (Figure 1). This information, transmitted via cell phone to a central database, provides an accurate picture of current stream levels.

The DNR and the IFC recently completed a pilot project to deploy a preliminary network of 50 sensors across the state. A statewide system that could be in place within a few years would enhance the ability to monitor stream stages and predict flooding.

Renewed state funding in 2010 and other grants allow the IFC to continue advancing our understanding of floods. In November 2010, for example, new funding from the U.S. Department of Housing and Urban Development was announced to support pilot projects that help Iowa minimize erosion, manage runoff, and mitigate future flood damage. This project and others to come will help ensure that Iowa is better prepared to handle inevitable future flooding.

To learn more about these projects and others at the IFC, visitwww.iowafloodcenter.org.

UNRAVELING WATER QUALITY AND QUANTITY EFFECTS OF BIOFUELS PRODUCTION

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National Laboratory for Agriculture and the Environment
USDA – Agricultural Research Service (ARS)

Developing a viable biofuels industry is crucial because: (1) we are rapidly approaching "peak oil" when all known, recoverable petroleum reserves will begin to diminish; (2) our dwindling global oil supplies will likely increase tension between petroleum suppliers and consumers; (3) oil price ultimately controls societal cost for food, feed, fiber, and manufactured goods; (4) oil use contributes to negative environmental impacts, including greenhouse gas (GHG) emissions; (5) oil supports current agricultural production systems that often have unintended environmental consequences, such as increased sedimentation, nutrient runoff, leaching and hypoxia; and (6) global demand for energy will increase as population and economic equity continue to rise. Sustainable production of many different biofuels will help to simultaneously address all of these complex interrelated challenges, but how will it affect our water resources? Winning a multimillion dollar lottery is undoubtedly easier than providing a definitive answer, but as students and teachers, it is imperative that we examine the multiple factors that make this seemingly simple question such a wicked challenge.

According to the U.S. Government Accountability Office (GAO), the impact of increased biofuels production on water resources will depend on the type of feedstock (the material used to produce biofuels such as corn grain, crop residue, switchgrass, miscanthus, poplar, or willow), how it's grown, and where it's grown. Different feedstocks use different amounts of water and different areas have more or less rainfall. The biofuels impact on water resources will also depend on the vulnerability of local water resources as well as the type of conversion process and the refinery's water use efficiency.

To understand the complexity of predicting biofuel effects on water quantity and quality, we must first step back from biofuels production per se and examine the global hydrologic cycle. In a recent viewpoint prepared for the Soil and Water Conservation Society, Dr. Warren Busscher, USDA-ARS (personal communication, 2010) pointed out that our planet is three quarters ocean, and although at first glance, one would expect that there would be enough water for everyone, 99% of that water is either too saline or exists as ice and therefore unavailable to humans. Less than 1% of global water exists in groundwater, lakes, or streams, and because of competition from industry, municipalities, and other energy producers, not all of that is available to agriculture or more specifically biofuels production. Currently, the U.S. uses 48% of its

fresh and weakly saline water for thermoelectric power generation, but evaporation and the power generation consume only 2 to 3% of this water. That is 97 to 98% of the water used for power generation is returned in its original form and is therefore potentially available for reuse, while 2 to 3% is lost by evaporation or becoming a part of the product. Municipal withdrawals account for another 10%, but nearly 90% of that water is returned as wastewater that can be treated and reused. Finally, industry accounts for another 21% of U.S. freshwater withdrawals, but the quantity and quality being returned is highly variable.

Agricultural water use differs from use by these other entities in that most of the water is consumed through evapotranspiration (ET) that supports plant growth and development. Water is also consumed when used to leach salts from the soil and thus manage soil salinity. With or without a biofuels industry, agriculture uses large quantities of water. Freshwater extraction ranges from less than 20% to more than 90% for different countries depending upon climate, productivity and water use efficiency (WUE) of the crops being grown. The ratio quantifying the amount of plant dry matter produced for a specific quantity of water used is defined as water use efficiency. The WUE value varies greatly depending on crop species, location, culture practice, climate and weather, and other factors. Growing plants is very water intensive because as much as 1000 pounds of water may be required to produce just one pound of plant material. Fortunately, the transpired water is recycled in the hydrologic cycle. It falls as precipitation, and after infiltrating into the soil, running off into streams or lakes, or percolating to deeper aquifers, it is once again available for ET in support of plant growth or other uses. Unfortunately, the groundwater portion of the cycle cannot always be replenished as fast as it is used in many drier regions and as a result groundwater is often irreversibly mined. The Ogallala Aquifer, located in the U.S. Great Plains, is one example where water mining has occurred. A 2009 U.S. Geological Survey (USGS) report stated that in parts of southwest Kansas and the Texas Panhandle, groundwater levels have dropped by more than 150 feet due to intensive crop irrigation and minimal aquifer recharge.

With a more complete understanding of the hydrologic cycle, we can now return to the core question – how will increased biofuels production affect water quantity and quality? As an agricultural product, the feedstock used for production of biofuels is highly dependent on water that can be provided through either rainfall or irrigation. Therefore, to accurately assess the impact of biofuels, the value of water and appropriateness of using it for feedstock production must be examined separately for rainfed and irrigated systems. Rainfed or natural systems where biomass production is based on water coming solely from precipitation can be sustained; water will not normally be limiting well into the future unless climate changes substantially. Conversely, if irrigation from a depleting aquifer is needed to produce feedstock for biofuels, there is little doubt the practice cannot be sustained. When the aquifer's water is gone, crop production ends. Additionally, several challenging questions must be asked: is the remaining water best used for human consumption, food production, recreation, or biofuel production? How important is using water to produce biofuel compared to other water uses when water is limited?

> The real impact of biofuels production on water use will therefore depend on which feedstock is being considered and where it is being grown.

Water is also important for conversion of feedstocks into biofuels, specifically for heating, cooling, and the chemical processes involved. For the corn based biofuels conversion process, water consumption has decreased dramatically during the past decade, falling from an average of 5.8 gallons of water per gallon of ethanol in 1998, to 3.0 gallons/gallon or less in 2009. For comparison, the recovery and refining of crude oil requires 3.6 to 7.0 gallons of water per gallon of fuel. Water requirements for conversion of cellulosic materials will depend on the feedstock and the conversion process. These systems are not fully developed, but current estimates of water use range from 1.9 to 6.0 gallons/gallon for ethanol production or 1.0 gallon/gallon for biodiesel.

The real impact of biofuels production on water use will

Table 1. Average irrigation-derived water consumption for corn grain ethanol production in the primary corn producing regions of the United States†.

Water Use	USDA Region 5 (Iowa, Indiana, Illinois, Ohio, & Missouri)	USDA Region 6 (Minnesota, Wisconsin, & Michigan)	USDA Region 7 (North Dakota, South Dakota, Nebraska, & Kansas)
	Gallons of water / gallons of ethanol		
Groundwater irrigation	6.7	10.7	281.2
Surface water irrigation	0.4	3.2	39.4
Total	7.1	13.9	320.6
Conversion	3.0	3.0	3.0
Total water consumption ‡	10.0	16.8	323.6

† Adapted from GAO-10-116 ‡ Not including precipitation

Table 2. Estimated evapotranspiration for selected potential biofuels feedstock crops in Illinois†.

Observation period	Rainfall (in)	PET (in)	Estimated ET (in)		
			Miscanthus	Switchgrass	Corn
2006 to 2008 average	15.83	24.57	14.49	9.76	10.39
14 May - 8 Oct. 2007	12.40	29.80	14.76	12.05	10.47
12 June - 19 Oct. 2006	15.04	21.50	15.00	7.99	10.75

†Adapted from McIsaac et al. 2010. J. Environ. Qual. 39:1790-1799.

therefore depend on which feedstock is being considered and where it is being grown. For corn, approximately 1.7 million gallons of water per acre are required to produce a crop averaging 225 bu/acre. Water use to grow the corn for each quarter section of land (160 acres) will therefore be approximately 272 million gallons which is similar to the 300 million gallons of water required annually for a 100 million gallon ethanol biofuels conversion facility. Approximately 160,000 acres of corn will be required to supply the corn grain for such a facility. The quantity of water needed to grow the feedstock (corn grain in this example) is orders of magnitude greater than that needed for converting feedstock to ethanol. For irrigated areas, the impact of water use by the conversion facility would be small compared to the amount of water used for crop production, but for communities where irrigation is not common, water withdrawal and use in the conversion facility would be relatively large and the main potential impact.

With regard to location, 89% of the U.S. corn crop in 2007 and 95% of the ethanol was produced in the upper and lower Midwest. Irrigation water use in this area ranges from 7 to 321 gallons of water per gallon of ethanol depending upon location. Obviously, climate is the driving force with North Dakota, South Dakota, Nebraska, and Kansas consuming an average of 865 gallons of irrigation-derived water per bushel of grain compared to between 19 and 38 gallons/bushel of irrigation-derived water in the predominantly rain-fed areas of Iowa, Illinois, Indiana, Ohio, Missouri, Minnesota, Michigan, and Wisconsin (Table 1).

Water use by feedstock for cellulosic biofuels is relatively unknown because they are not being grown at a commercial scale. However, cellulosic feedstock is expected to have less water use impact for several reasons.

First, agricultural residues (e.g. corn stover, wheat or rice straw, sugarcane bagasse) are co-products for which water use is generally calculated based on grain or sugar production. Therefore, many people argue that no additional water is required for those materials. Perennial grasses (e.g. switchgrass, miscanthus, mixed prairie) may require less water than corn grain provided adequate supplies can be produced without irrigation, but if rainfall is limited, water use may actually be greater (See Table 2). For students and teachers interested in learning more about crop water use and its potential impact on ethanol production, please see http://www.ars.usda.gov/main/site_main.htm?modecode=54-07-00-00 and select the section entitled "Products and Services."

With regard to water quality, there is generally greater concern regarding increased corn production as a biofuel feedstock because of the potential for increased runoff and leaching of nutrients into lakes and streams. There is also concern that if prices for biofuels feedstock increase, marginal lands will once again be brought into row crop production without proper soil and water conservation practices. If this occurs, higher applications of fertilizers and pesticides to support feedstock production could result in greater delivery of sediment, nutrients, and pesticides to surrounding water resources. Biofuels production could also affect water quality as a result of the contaminate discharge from conversion facilities. However, once again the type of contaminants and discharge rates are mostly unknown for cellulosic conversion to biofuels because of potential differences in the conversion processes.

With equal vigor, others argue that increased perennial plant lignocellulosic feedstock production, especially in marginal lands and selected environmentally sensitive areas, would improve soil and water quality by intercepting runoff and capturing nutrients moving through the shallow groundwater flow. Use of diverse cellulosic feedstocks as buffers between intensive crop production areas and vulnerable water quality areas is the basis for managing biofuels production systems using a "landscape vision." Diverse management zones could be created starting with deep-rooted woody species near streams with adapted, deep-rooted perennial grasses between the trees and grain crops. Such a landscape design would provide multiple ecosystem services, especially with regard to reducing the contaminant load entering streams.

In summary, passage of the Energy Independence and Security Act (EISA) of 2007 requiring increased biofuel use in the U.S. raised many unanswered questions including the probable effects of biofuels on water quantity and quality. Undoubtedly, the most realistic answer to that question is "It Depends." This may not be a satisfying answer for many readers, but hopefully this article has provided a better understanding of how complex and difficult it is to answer this seemingly simple question.

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